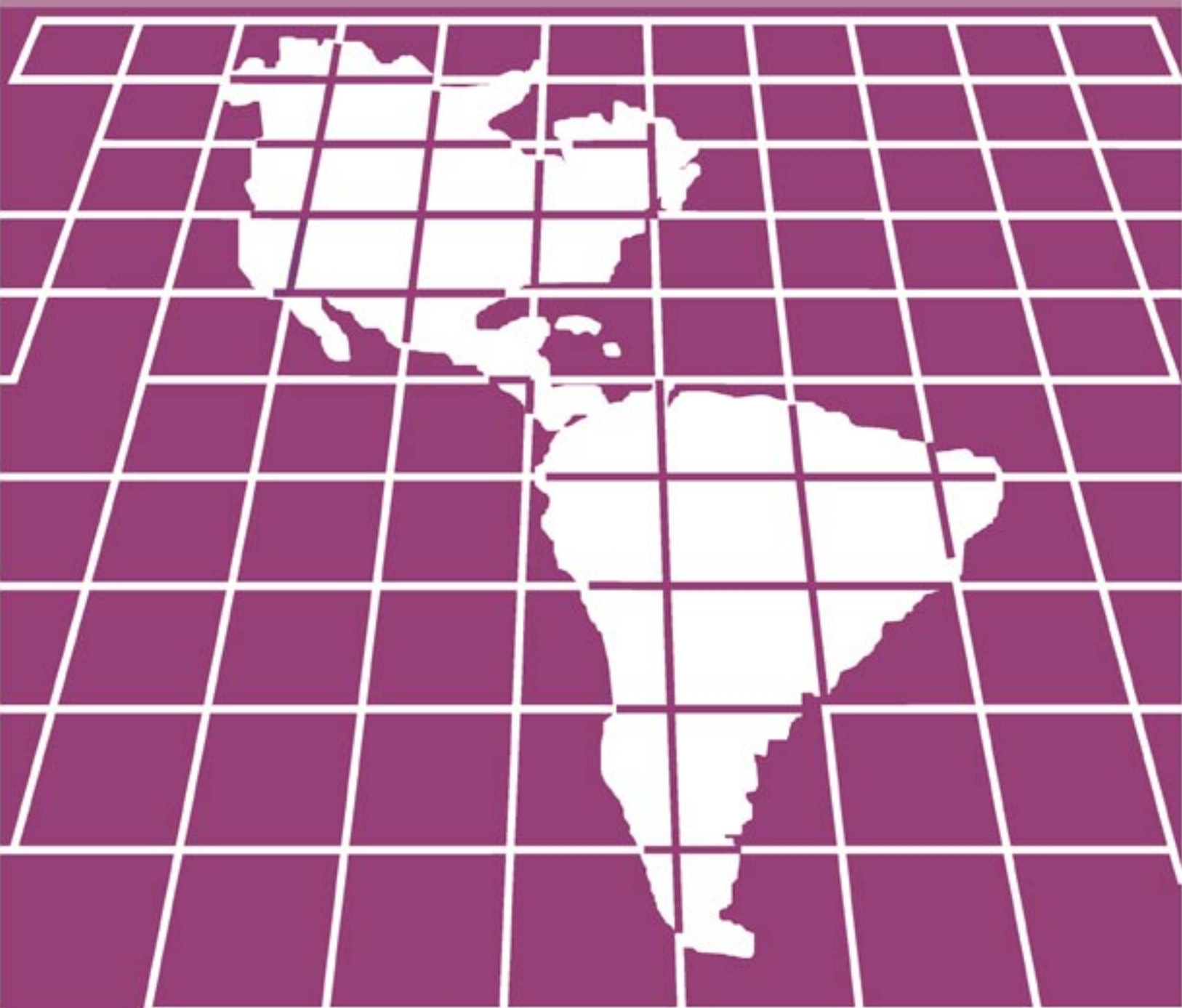
PANAMERICAN JOURNAL OF TRAUMA

ISSN 0121 - 5396

SOCIEDAD PANAMERICANA DE TRAUMA
SOCIEDADE PANAMERICANA DE TRAUMA
PANAMERICAN TRAUMA SOCIETY

Vol. 11 N° 2 2004



PANAMERICAN JOURNAL OF TRAUMA

INSTRUCTIONS FOR AUTHORS

Manuscripts and related correspondence should be sent to either Dr. Kimball Maull MD or Dr. Ricardo Ferrada MD to the following addresses:
Kimball Maull, M.D. FACS, Carraway Medical Center, 1600 Carraway Boulevard, Birmingham, Alabama USA.

1. ***Manuscript.*** The original typescript and two high-quality copies of all illustrations, legends, tables and references must be submitted. All copy, including references, must be typed double-spaced on 21 x 27 cm, heavy-duty white bond paper. Margins must be at least 1 inch. A computer diskette or CD containing a file of the article must be included. Files in Word either for IBM-compatible or Apple are preferred. The diskette should be labeled with the author's names, the title of the article, the type of computer, and the word processing software used.
2. ***Title***. The title must be short, specific and clear. It cannot exceed 45 characters per line, and is limited to two lines. The title page should include the full names, and academic affiliations of all author. Foot notes indicating where the works was done, where orders for reprints should be addressed and those contributing grants for the work should be given at the bottom of the second page. If the manuscript was presented at a meeting, indicate the name of the organization, the place and the date on which it was read.
3. ***Illustrations.*** Please send three complete sets of high contrast glossy prints. Figure number, name of senior author, and arrow indicating top should be typed on a gummed label and affixed to the back of each illustration. Cost of color figures, where used, is borne by authors.
4. ***Summary.*** A summary of 150 words or less should be submitted in English and Spanish. The summary must include a statement of the problem, methods of study, results and conclusions. A list of key words to be used for indexing should appear at the end of the summary.
5. ***References.*** References should be listed in consecutive numerical order as they are cited in the text. Once a reference is cited, all subsequent citations should be to the original number. All references must be cited in the text or tables. References to journal articles should include: authors, title, journal name as abbreviated in Index Medicus, year, volume number, and inclusive page numbers in that order. References to books should include: authors, chapter title, if any; editor in any; title of book; year; city and publisher. Volume and edition numbers, specific pages, and name of translator should be included when appropriate. The author is responsible for the accuracy and completeness of the references and for their correct text citation.
6. ***Originality & copyright.*** Manuscripts and illustrations submitted for consideration should not have been published elsewhere except for such preliminary material presented to the Panamerican Trauma Society.

INSTRUCCIONES PARA LOS AUTORES

Los manuscritos y la correspondencia se deben enviar a Ricardo Ferrada MD o Kimball Maull MD a las siguientes direcciones: **Ricardo Ferrada, M.D., FACS Departamento de Cirugía, Hospital Universitario del Valle, Calle 5 # 36-08, Cali, Colombia, S.A.**

1. ***Manuscritos.*** Se debe enviar un original del manuscrito y dos copias de todas las ilustraciones, leyendas, cuadros y referencias. Todas las copias, incluso las referencias, deben ser escritas a doble espacio en papel blanco de 21 x 27 cm. Los márgenes deben ser amplios. Se debe incluir un diskette o CD que contenga el artículo. Son preferibles los archivos en Word IBM compatibles o Apple. El diskette debe ser marcado con el nombre del artículo y de los autores, el tipo de sistema operativo y el procesador de palabras utilizado.
2. ***Título.*** El título debe ser corto, claro y específico. No puede exceder de 45 caracteres por línea y está limitado a dos líneas. La página del título incluye el nombre completo y la posición académica de los autores. En la parte inferior de la segunda página se debe indicar dónde se llevó a cabo el trabajo, la dirección para los reimpresos y las donaciones recibidas para su realización. Si el manuscrito se presentó en una reunión científica, indicar el nombre de la organización, el lugar y la fecha de presentación.
3. ***Ilustraciones.*** Por favor enviar tres copias completas de las ilustraciones en alto contraste en papel brillante. En la parte posterior de cada ilustración anote el número de la figura, el autor principal y una flecha con la punta hacia el borde superior. Si existen figuras a color, el costo será cubierto por los autores.
4. ***Resumen.*** No debe tener más de 150 palabras y debe ser enviado en español y en inglés. El resumen incluye una definición del problema, los métodos de estudio, los resultados y las conclusiones. Al final del resumen se debe adjuntar una lista de palabras claves para efectos de índice.
5. ***Referencias.*** Las referencias se citan en orden numérico consecutivo, tal como aparecen en el texto, e incluyen el siguiente ordenamiento: autores, título en el idioma original, nombre de la revista en su forma abreviada según el Index Medicus, año de publicación, volumen de la revista y páginas iniciales y finales. Se recomienda citar hasta cuatro autores en forma completa. Si hay más de cuatro autores, después del tercero, seguido por una coma, se colocan las palabras latinas et al. Las citas de libros incluyen: autores o editor y así se debe identificar (ed.), título del libro, edición, ciudad de publicación, la empresa editorial y año. Las referencias deben ser verificadas por los autores y ésta es una de sus responsabilidades.
6. ***Originalidad y derechos de autor.*** Los manuscritos deben ser inéditos y no haber sido publicados en otra parte, excepto como material presentado a la Sociedad Panamericana de Trauma.

PANAMERICAN JOURNAL OF TRAUMA

Editors:
RICARDO FERRADA, M.D., Cali, Colombia
RAO IVATURY M.D., Richmond, Virginia
DARIO BIROLINI, M.D., Sao Paulo, Brazil

Assistant Editors:
SAMIR RASSLAN M.D., Sao Paulo, Brazil
ANDREW PEITZMAN M.D., Pittsburgh, Pennsylvania
JORGE NEIRA, M.D., Buenos Aires, Argentina

RAFAEL ANDRADE, M.D.
Panama, Panama
JUAN ASENSIO, M.D.
Los Angeles, California
CARLOS BARBA, M.D.
Hartford, Connecticut
LUIS BAEZ, M.D.
Caracas, Venezuela
MARY BEACHLEY, R.N.
Baltimore, Maryland
RICARDO ESPINOZA M.D.
Santiago, Chile
EUGENE FAIST, M.D.
Münich, Germany
DAVID FELICIANO, M.D.
Atlanta, Georgia
ALBERTO GARCIA, M.D.
Cali, Colombia
LUIS GRANJA MENA, M.D.
Quito, Ecuador
GERARDO GOMEZ, M.D.
Indianapolis, Indiana
FRANCISCO HOLGUIN, M.D.
Cartagena, Colombia
LENWORTH M. JACOBS, M.D.
Hartford, Connecticut
TEOFILO LAMA PICO, M.D.
Guayaquil, Ecuador
CHARLES LUCAS, M.D.
Detroit, Michigan
ROBERT MACKERSIE, M.D.
San Francisco, California
KATZIUKO MAEKAWA, M.D.
Kitasato, Japan
KIMBALL MAULL, M.D.
Birmingham, Alabama
ERNEST E. MOORE, M.D.
Denver, Colorado
DAVID MULDER , M.D.
Montreal, Canadá
DAVID ORTEGA, M.D.
Lima, Peru
RENATO POGGETTI, M.D.
Sao Paulo, Brazil
ABRAHAM I RIVKIND, M.D.
Jerusalem, Israel
AURELIO RODRIGUEZ, M.D.
Pittsburgh, Pennsylvania
CLAYTON SHATNEY, M.D.
San Jose, California
RAUL COIMBRA M.D.
San Diego, California
JOSE TROSTCHANSY, M.D.
Montevideo, Uruguay
JOSE MARIO VEGA, M.D.
San Salvador, El Salvador

SECTION EDITORS

Critical Care:
DAVID HOYT, M.D.
San Diego, California

Emergengy & Disaster
SUSAN BRIGGS, M.D.
Boston, Massachusetts

Infection:
RONALD MAIER, M.D.
Seattle, Washington

Nursing:
ROBBIE HARTSOCK, R.N.
Baltimore, Maryland
VIVIAN LANE, R.N.
Hartford, Connecticut

Orthopedic Trauma:
BRUCE BROWNER, M.D.
Hartford, Connecticut

Pediatrics:
MARTIN EICHELBERGER, M.D.
Washington, D.C.

Plastic Surgery:
DAVID REATH, M.D.
Knoxville, Tennessee

Prehospital Care:
ALEJANDRO GRIFE, M.D.
Mexico, Mexico

Coordinación Editorial:
DISTRIBUNA
Editorial y Librería Médica
Autopista Norte 123 - 93
Fax: (1) 2132379
Tel: (1) 2132379 - (1) 2158535
Celular: 3108739208 - 3157938377
Apartado Aéreo: 265006
Bogotá - Colombia
www.libreriamedica.com
Impreso: Editora Guadalupe

PANAMERICAN JOURNAL OF TRAUMA

CONTENT CONTENIDO

DIAGNOSTIC MODALITIES FOR PENETRATING ABDOMINAL INJURIES

Charles E. Lucas, MD, FACS, Robert S. Crawford, MD.

SUMMARY

With the exception of the patient intoxicated with alcohol and the patient with acute spinal cord injury, the most important diagnostic study for penetrating abdominal injuries is the physical examination. Eviscerated patients can be managed in two ways. Those who present with simultaneous hypotension should be taken immediately to the operating room for continued resuscitation and treatment of injuries. Stable patients can be resuscitated, evaluated and anesthetized before definitive return of eviscerated organs. The same philosophy may be applied to the evaluative sequence of the patient with any injury following penetrating abdominal trauma. Several diagnostic test may be used to establish violation of the peritoneum from penetrating abdominal injuries (DPL, digital examination, sinogram); however, the experience of the authors points to the re-establishment of serial physical examination as the most important diagnostic modality after a stab wound to the abdomen. With some exceptions (obese patient, right upper quadrant and flank wounds), patients with abdominal gunshot wounds present with a higher incidence of serious injury for which they generally undergo special diagnostic tests and exploratory laparotomy. A high index of suspicion, and the correct diagnostic studies are needed to diagnose lower abdominal, pelvic and thoracoabdominal injuries.

Keywords

Abdomen, Penetrating, Evisceration, Diagnosis, Treatment.

Profesor of Surgery, Wayne State University.

RESUMEN

El examen fisico continua siendo el componente mas importante para la evaluación del paciente con trauma penetrante, a excepción del paciente intoxicado con alcohol, o del paciente con trauma de la espina dorsal. Los pacientes eviscerados se pueden manejar de dos maneras. Aquellos que presentan simultaneamente hipotensión deben ser transportados inmediatamente a la sala de operaciones para continuar su resucitación y el tratamiento de sus heridas. Los pacientes estables pueden ser resucitados, evaluados y anestesiados antes de retornar los órganos eviscerados a la cavidad. La misma filosofia puede ser aplicada para evaluar a pacientes con heridas penetrantes de abdomen. Varios exámenes diagnósticos pueden ser utilizados para establecer violación del peritoneo producido por trauma abdominal penetrante (DPL, examen digital, sinograma); sin embargo, la experiencia de los autores apunta a el re-establecimiento del examen fisico como la modalidad diagnóstica mas importante para evaluar pacientes con trauma penetrante de abdomen. Con pocas excepciones (pacientes obesos, heridas en el cuadrante superior derecho o en los flancos), pacientes con heridas producidas por armas de fuego presentan con una mayor incidencia de gravedad, por lo que generalmente se los somete a examenes especiales de diagnóstico y laparotomia exploratoria. Un alto indice de sospecha, y los examenes de diagnóstico apropiados, son necesarios para identificar heridas abdominales, pélvicas o toraco-abdominales.

Palabras clave

Abdomen, Penetrante, Evisceración, Diagnosis, Tratamiento.

The first and most important diagnostic modality for penetrating abdominal wounds is the physical examination. Whenever a patient presents with hypotension following an isolated stab wound or gunshot wound to the abdomen, he should be taken directly to the operating room for control of hemorrhage.[1] There are two common circumstances in which this general policy will lead to a non-therapeutic laparotomy. The first occurs in the patient who is intoxicated with alcohol and has sustained minor blood loss, possibly, through the stab wound from the abdominal muscles. Such patients typically reek of alcohol and respond rapidly to the infusion of two liters of balanced electrolyte solution.[2] The second classic exception occurs in the patient with acute spinal cord injury and minimal blood loss but without normal peripheral vasomotor response. This combination is rapidly identified by the rectal examination which shows lack of tone and by the quick physical examination which reveals paralysis and no sensation in the lower extremities. When acute spinal cord injury is present, the addition of a low dose vasoactive substance, such as Dopamine, will restore lower limb tone and systolic blood pressure. The last thing that an acute paraplegic patient needs is a non-therapeutic laparotomy which compromises the later hospital course, particularly, as it relates to pulmonary function.[3]

APPROACH TO EVISCERATION

The patient who presents with the combination of hypotension and abdominal evisceration requires rapid transport to the operating room where resuscitation is continued as the patient is anesthetized for laparotomy, intraoperative diagnosis, and treatment of injuries. When the patient with evisceration has normal vital signs, the exposed viscera should be covered by a moist towel and the patient taken to the operating room while being resuscitated so that he can be anesthetized and the eviscerated organs gently returned to the peritoneal cavity. Attempts to restore the viscera without anesthesia and full relaxation will be futile. If perforations are present in the eviscerated intestines and the anesthetized patient is stable, the perforations should be closed with a running absorbable suture and then thoroughly irrigated prior to returning the organs to the peritoneal cavity. The second layer of the closure and the remainder of diagnostic steps followed by definitive treatment can be carried out through the subsequent laparotomy incision.[4,5] When emergent laparotomy precludes preoperative testing, the retroperitoneal duodenum and pancreas, the portal triad structures, the urologic organs, and the great vessels should be examined visually and digitally. Suspected urologic system injury can be assessed in the operating room by a drip infusion polygram utilizing a 250 ml bolus of a solution containing 50 percent contrast agent and 50 percent saline given over five minutes while obtaining an intraoperative abdominal film at one minute and at five minutes. This study will give excellent visualization of the kidneys and both ureters, thus, circumventing the need to dissect these areas in all patients. Any question regarding bladder perforation at the time of laparotomy can be resolved by a cystogram performed on the table.[6]

ABDOMINAL STAB WOUNDS

The approach to a patient with an abdominal stab wound varies according to one's philosophy of treatment. Several years ago, almost all trauma surgeons followed the policy of exploring all patients with a stab wound thought to penetrate the peritoneum. When this policy is followed, the surgeon wishes to know when a knife has actually entered the peritoneum cavity to avoid doing a non-therapeutic laparotomy in a patient without a penetrating wound. Several tests can be used to define peritoneal penetration. The simplest is a digital examination of the stab wound to determine if the finger penetrates into the peritoneal cavity.[7,8] Another technique is local exploration of the wound, incising down to the external oblique fascia or the anterior rectus sheath. When either is perforated, peritoneal penetration is presumed. A third test of penetration is the sinogram, whereby, a Foley catheter is placed through the skin wound and the balloon inflated to prevent leakage of two ounces of contrast agent which is injected through the catheter followed by the attainment of posterior-anterior, lateral and tangential x-rays of the abdomen to determine if the contrast agent enters into the peritoneal cavity.[9] Finally, diagnostic peritoneal lavage (DPL) utilizing the standard techniques can quite accurately identify that a knife has entered the peritoneal cavity whenever any amount of blood is returned on the lavage fluid. All of these tests have a predictable but low percent of false-positive results;

thus, they are good guides for identifying penetration for surgeons who explore all penetrating stab wounds.[10,11]

Many years ago, one of the authors (CEL) was assigned the task of reviewing laparotomies for stab wounds performed at the Detroit Receiving Hospital over a five-year period. Approximately 750 records were painfully evaluated and the results were categorized into four groups: group 1 - patients operated upon for a non-penetrating injury; group 2 - patients with penetration but no organ injury; group 3 - patients with minor organ injury which was not life-threatening, such as a partial thickness bowel perforation or a non-bleeding stab of the liver with less than 500 mL blood within the peritoneal cavity, and group 4 - patients with life-threatening injuries including full-thickness hollow viscus perforation and sold viscus injury associated with more than 500 ml blood in the peritoneal cavity regardless of whether the wound was still bleeding. Clearly, some of the patients categorized in group 4 would have survived without laparotomy. The breakdown for these 750 patients was 18 percent for group 1, 26 percent for group 2, 29 percent for group 3 and 27 percent for group 4. Consequently, over 73 percent of these patients underwent a non-therapeutic laparotomy. These results and similar results obtained from many trauma centers in North America led to acceptance by most surgeons that laparotomy following a stab wound to the abdomen should be based upon physical and radiographic finding independent as whether the wound actually penetrated the peritoneum.[12,13]

The most important consequence of these findings is the re-establishment of serial physical examination as the most important diagnostic modality after a stab wound of the abdomen.[14] This examination, in the sober patient, focuses on altered pulse rate and blood pressure, particularly a reduction in pulse pressure soon after admission to the Emergency Department or on the development of abdominal tenderness. Clinical hypovolemia in the absence of spinal cord injury or high alcohol content is an indication for laparotomy for presumed hemoperitoneum.[3] When some questions exist about the origin of hypotension, a diagnostic paracentesis (DPC) performed bilaterally along the lateral recti borders can be performed in about 30 seconds. When bilateral DPC yields no blood, the surgeon should suspect that hypovolemia is due to an extraabdominal source. While resuscitation continues, the surgeon may perform an ultrasound examination looking for free fluid within the peritoneal cavity or perform a rapid (five minutes) DPL. Whenever ultrasound and DPL are negative, the hypotension is clearly caused by something outside of the peritoneal cavity. While resuscitation continues, the surgeon needs to identify another source of bleeding.[15,16]

Patients presenting with evidence of peritoneal irritation as exhibited by pain and tenderness distant from the actual stab wound require laparotomy to repair presumed hollow viscus injuries. Ultrasound examination in this setting may be negative even though the patient has a hollow viscus perforation. Likewise, the DPC is likely to be negative and the DPL may be negative if performed shortly after the patient arrives. The classic studies of DPL showing leukocytosis greater than 500 WBCS/per ml^3 reflect small bowel injuries which have been present for at least two hours. Systematic blood chemistries at this time are of little benefit. When there has been delay in patient presentation following an abdominal stab wound, the DPL will become positive, showing leukocytosis, amylase elevation, and sometimes an elevation in the alkaline phosphatase.

There is one classic example where diffuse abdominal pain following a stab wound to the upper abdomen or lower thoracic areas will lead to a non-therapeutic laparotomy. This occurs in the patient who has a stab wound of the lower rib cage often associated with a hemopneumothorax requiring a chest tube thoracostomy. Such a patient may have referred pain along the distribution of the intercostal nerve which causes pain and tenderness down to the midline over the anatomic course of that nerve. When some question exist about the etiology of this localized pain, a rib block performed proximal to the stab wound will totally eliminate the pain and tenderness and confirm that this is somatic pain rather than viscera pain. Following these guidelines, the incidence of a non-therapeutic laparotomy will be markedly reduced except in patients who are intoxicated and complain of pain everywhere in the abdomen while not recognizing that such complaints are going to lead to a non-therapeutic laparotomy. Diagnostic laparoscopy in this setting may circumvent full laparotomy. The surgeon has no option but to explore the patient complaining of diffuse abdominal pain following an abdominal stab wound.[17]

APPROACH TO ABDOMINAL GUNSHOT WOUNDS

The prime difference in the diagnostic approach to an abdominal gunshot wound compared to the stab wound reflects the high incidence of serious injury when the missile enters the peritoneal cavity. Consequently, the vast majority of patients with penetrating gunshot wounds routinely undergo exploratory laparotomy without the need for special diagnostic studies. There are certain exceptions to this general principle. The patients presenting with a gunshot wound to the right upper quadrant causing an associated hemothorax which is treated by tube thoracostomy may be selectively observed if vital signs remain stable. Such patients certainly have a through-and-through injury to the liver and the right hemidiaphragm but both injuries often respond without definitive repair.[7] Although the safety of this approach has been well documented in patients with stable vital signs, the authors prefer the operative approach with primary closure of the diaphragmatic perforation and examination with possible drainage of the through-and-through liver laceration. Another exception to routine exploration would be the patient who is rather obese and has an abdominal bullet track which may pass tangentially through the abdominal wall musculature without entering into the peritoneal cavity. Such patients will have a negative abdominal ultrasound and DPL. When using a DPL to determine the presence of penetration, any amount of blood seen on the returning effluent signifies a probable peritoneal penetration. Definitive visualization of the bullet track can be made by the abdominal CAT scan which confirms that the bullet never penetrated the peritoneum. Gunshot wounds to the flank may also be examined by abdominal CAT scan which will show that the bullet path does not enter the peritoneum or injure the retroperitoneal colon or duodenum. A DPL may be negative when the bullet has caused a through-and-through perforation of a retroperitoneal hollow viscus. If retroperitoneal hollow viscus injury is suspected because of peritoneal signs, a definitive diagnosis may be made by a triple contrast CAT scan of the abdomen. In this setting, however, the authors prefer exploratory laparotomy.[18,19,20]

LOWER ABDOMINAL AND PELVIC WOUNDS

Gunshot wounds to the lower abdomen, pelvis and buttocks present special diagnostic problems. The presence of a low urethral injury or bladder perforation may not be appreciated by ultrasonography, DPL or contrast CAT scan of abdomen and pelvis. The presence of microscopic hematuria in any patient with a bullet path near the bladder should be followed up with cystoscopy or cystography to rule out a retroperitoneal bladder injury.[21] Likewise, careful digital examination of the rectum looking for blood is essential. When the rectal vault is full of stool, evacuation and proctoscopy will help identify low-lying rectal perforations. When complete evacuation is not accomplished, the patient should be suspected of having a rectosigmoid or rectal injury until full evacuation is accomplished and injury is ruled out by means of endoscopy. When injury is identified, the surgeon should presume that the bacteria passing with the missile outside the rectum will cause infectious problems along the missile path. In contrast, intraperitoneal bladder rupture and intraperitoneal colon rupture will be suspected on the basis of physical examination and more easily confirmed by means of ultrasonography and DPL.[22,23,24]

THORACOABDOMINAL WOUNDS

Penetrating gunshot wounds and stab wounds to the lower rib cage may cause hemothorax and be associated with a diaphragmatic penetration. The diaphragmatic penetration is often asymptomatic but may be suspected by the location and confirmed by a DPL yielding any amount of blood on the effluent or by laparoscopy. If identified by laparoscopy and no other intraabdominal injuries are present, the diaphragmatic perforation should the laparoscopically closed. When this entity occurs on the right side, simple drainage of the right hemithorax will usually suffice without laparotomy since the liver will impede subsequent bowel herniation through the diaphragmatic perforation.[25]

When a patient with a penetrating wound to the lower ribs complains of pain in the upper quadrant extending

to the midline, one should suspect referred pain from contusion of the intercostal nerves. This is true for both gunshot wounds as well as stab wounds as previously noted. Both the diagnostic and treatment in this setting are performed by the intercostal nerve block. Seldom does the patient need a second rib block for this type of referred pain.

BIBLIOGRAPHY

1. *Van Haarst EP, Van Bezooijen BPJ, Coene PP, et al: The efficacy of serial physical examination in penetrating abdominal trauma. Injury 1999;30:599-604.*

2. *Jurkovich GJ, Rivara FP, Gurney JG, et al: The effect of acute alcohol intoxication and chronic alcohol abuse on outcome from trauma. JAMA 1993;270:51-56.*

3. *Zipnick RI, Scalea TM, Trooskin SZ, et al: Hemodynamic responses to penetrating spinal cord injuries. J Trauma 1993;35:578-583.*

4. *McFarlane MEC: Non-operative management of stab wounds to the abdomen with omental evisceration. J R Coll Surg Edinb 1996;41:239-240.*

5. *Medina M, Ivatury RR, Stahl WM: Omental evisceration through an abdominal stab wound: Is exploratory laparotomy mandatory? 1984;27:399-401.*

6. *Nagy KK, Roberts, Joseph K, et al: Evisceration after abdominal stab wounds: Is laparotomy require? J Trauma 1999;47:622-626.*

7. *Morales CH, Villegas MI, Angel W, et al: Value of digital exploration for diagnosing injuries to the left side of the diaphragm caused by stab wounds. Arch Surg 2001;136: 1131-1135.*

8. *Rosenthal RE, Smith J, Walls RN, et al: Stab wounds to the abdomen failure of blunt probing to predict peritoneal penetration. Ann Emerg Med 1987;16:172-174.*

9. *Lucas CE: Percutaneous diagnostic puncture of the peritoneal cavity. Ann Surg Resident's Edition 1992;216.*

10. *Brackenridge, SC, Nagy KK, Joseph KT, et al: Detection of intra-abdominal injury using diagnostic peritoneal lavage after shotgun wound to the abdomen. J Trauma 2003;54: 329-331.*

11. *Sriussadaporn, Pak-art R, Pattaratiwanon M, et al: Clinical uses of diagnostic peritoneal lavage in stab wounds of the anterior abdomen. A prospective study. Eur J Surg 2002;168: 490-493.*

12. *Haan J, Kole K, Brunetti A, et al: Nontherapeutic laparotomies revisited. Am Surg 2003;7:562-565.*

13. *Simon RJ, Rabin J, Kuhls D: Impact of increased use of laparotomy on negative laparotomy rates after penetrating trauma. J Trauma 2003;53:297-302.*

14. *Zubowski R, Nallathambi M, Ivatury R, et al: Selective conservatism in abdominal wounds: The efficacy of serial physical examination. J Trauma 1998;28:1665-1668.*

15. *Rosemurgy AS, Albrink MH, Olson SM, et al: Abdominal stab wound protocol: Prospective study documents applicability for widespread use. Am Surg 1995;61:112-116.*

16. *Udobi KF, Rodriguez A, Chiu WC, et al: Role of ultrasonography in penetrating abdominal trauma: A prospective clinical study. J Trauma 2001;50:475-479.*

17. *Asensio JA, Arroyo H, Veloz W, et al: Penetrating thoracoabdominal injuries: Ongoing dilemma-which cavity and when? Word J Surg 2002;26:539-543.*

18. *Shanmuganathan KS, Mirvis SE, Chiu WC, et al: Triple-contrast helical CT in penetrating torso trauma: A prospective study to determine peritoneal violation and the need for laparotomy. AJR Am J Roentgenol 2001;177:1247-56.*

19. *Velmahos GC, Demetriades D, Toutouzas KG, et al: Selective nonoperative management in 1,856 patients with abdominal gunshot wounds: Should routine laparotomy still be the standard of care? Ann Surg 2001;234:395-403.*

20. *Lucas CE, Ledgerwood AM: Injuries to the stomach, duodenum, pancreas, small bowel, colon and rectum. ACS Surgery Principles and Practice 2003. Eds. Wilmore, Cheung, Harken, Holcroft, Meakins, Soper. WebMD Inc, New York, NY. 2003;420-431.*

21. *Nagy KK, Brenneman FD, Krosner SM, et al: Routine preoperative "one-shot" intravenous pyelography is not indicated in all patients with penetrating abdominal trauma. J Am Coll Surg 1997;185:530-533.*

22. *Tiguert R, Harb JF, Hurley PM, et al: Management of shotgun injuries to the pelvis and lower genitourinary system. Urology 2000;55:193-197.*

23. *Velmahos GC, Demetriades D, Cornwell EE, et al: Gunshot wounds to the buttocks: Predicting the need for operation. Dis Colon Rectum 1997;40:307-311.*

24. *Velmahos GC, Gomez H, Falabella A, et al: Operative management of civilian rectal gunshot wounds: Simpler is better. World J Surg 2000;24:114-118.*

25. *Shatney CH, Sensaki K, Morgan L: The nature history of stab wounds of the diaphragm: Implications for a new management scheme for patients with penetrating thoracoabdominal trauma. Am Surg 2003;69:508-513.*

DISCONTINUANCE OF RESUSCITATION AFTER INJURY

Charles E. Lucas, MD, FACS, Robert S. Crawford, MD

SUMMARY

The decision making to cease resuscitation of injured patients is ideally based on hard data, whereas many of the recommendations or guidelines are intuitive. The earliest choice regarding the continuance of resuscitation is made by the EMT. Patients without vitals signs or those who sustain cardiovascular collapse after blunt trauma have essentially zero chance of long term success. Patients with cardiovascular collapse after penetrating trauma and especially those with penetrating wounds to the chest have the best chance of success. Resuscitation continues in the emergency room. Here, cross clamping of the thoracic aorta, may be applied to patients with penetrating abdominal trauma. The greatest likelihood for successful resuscitation in the ER occurs in the patient with a penetrating chest wound. Resuscitation in the OR is continued for patients who responded to ER thoracotomy, pericardiotomy, release of tamponade and/or cardiorrhaphy. Improved outcome can be expected for patients in which large vessel bleeding has been controlled, irregardless of implementation of abdominal packs. The authors recommend routine administration of FFP and platelets in defined amounts to slow down the development of coagulopathy. Continued efforts to control bleeding in the setting of coagulopathy has made resuscitation in the SICU a viable option. The key to its success is to know when to initiate packing and when to return to the OR after successful resuscitation and restoration of hydration, acid base balance and coagulation status. Multiple organ failure is the ultimate challenge facing the patient in the SICU. The occurrence of brain injury, the pre-injury state of the patient, the development of renal and hepatic dysfunction, and the age of the patient all affect morbidity and mortality in the SICU. A general philosophy to follow is that resuscitation in the SICU should be continued in a manner compatible with the surgeon's own wishes if he/she were the patient being treated.

Keywords

Resuscitation, Discontinuation, Pre-hospital, Emergency, Operating Room, SICU

RESUMEN

La decisión de terminar la resucitación del paciente traumatizado esta basada idealmente en datos precisos, aunque muchas de las recomendaciones e indicaciones son intuitivas. La primera opción relacionada con la continuación de la resucitación la realiza el tecnólogo de ambulancia o paramédico. Los pacientes sin signos vitales, o aquellos que sufren colapso cardiovascular luego de trauma no penetrante, tienen esencialmente cero porcentaje de sobrevida a largo plazo. Los pacientes con colapso cardiovascular luego de trauma penetrante, especialmente aquellos con heridas penetrantes de tórax, tienen la mejor oportunidad de sobrevida. La resucitación continúa en la emergencia. Allí, el clampeo de la aorta, se puede aplicar a los pacientes con trauma penetrante de abdomen. La mejor oportunidad de resucitación en la emergencia ocurre en el paciente con herida penetrante de torso. La resucitación en la sala de operaciones continúa para pacientes que respondieron a una toracotomía, pericardiotomía, o manejo de laceración o taponamiento cardiaco en la emergencia. Se puede esperar un mejor

Professor of Surgery, Wayne State University.

índice de sobrevida en pacientes en los cuales se logra controlar el sangrado proveniente de vasos mayores, sin el uso de empaquetamiento abdominal. Los autores recomiendan el uso de plasma y plaquetas en unidades determinadas para frenar la progresión de las coagulopatías. Los esfuerzos continuos para controlar el sangrado en caso de coagulopatía ha hecho de la resucitación en el cuidado intensivo una opción viable. La clave del éxito es saber cuando comenzar el packing abdominal y cuando regresar a la sala de operaciones. La falla orgánica múltiple es el mayor desafío que enfrenta al paciente en el cuidado intensivo. El trauma cerebral, el estado de salud del paciente previo al trauma, la aparición de falla hepática y renal y la edad del paciente afectan la morbididad y la mortalidad del paciente en el cuidado intensivo. Una filosofia general a seguir es que la resucitación en el cuidado intensivo debe continuar de una manera compatible con los deseos del cirujano si es que él o ella fueran los pacientes tratados.

Palabras clave

Resucitación, Descontinuamiento, Pre-hospital, Emergencia, Sala Operatoria, UCI.

The decision to cease resuscitation of the injured patient varies with a multitude of factors including the type and severity of injury, patient age, comorbid conditions and the stage of the recovery process. This decision may be made early after a lethal injury or late in a patient who has recovered from hemorrhagic shock but is suffering from multiple organ failure. Decision-making is ideally based upon hard data, whereas, many of the recommendations or guidelines are intuitive. Intuition, in turn, varies with experience.[1,2,3]

PRE-HOSPITAL RESUSCITATION

The earliest choice regarding the continuance of resuscitation is made by the Emergency Medical Technicians (EMT). When called to resuscitate a patient who is found without vital signs or responsiveness and is cold, the best decision is to confirm that the patient is dead; attempts at Lazaran efforts are unwarranted.[4] The nihilistic decision to cease resuscitation is much more difficult when informed by those present that the patient just stopped breathing and is still warm. Institution of cardiopulmonary resuscitation (CPR) in this setting will occasionally restore circulation but the likelihood of long-term success is very low. The EMT team, after initiating resuscitation, will need to reassess the circumstances which led to the cardiovascular collapse. When the initial insult was the result of a blunt force such as a motor vehicle collision (MVC) causing multiple fractures including a pelvic fracture, the chances for long-term success are essentially zero and the CPR can be discontinued.[5] In contrast, there will be minimal success in patients who develop cardiovascular collapse after penetrating trauma and CPR can be continued, particularly if there is a response. The addition of intravenous fluids and vasoactive drugs may restore perfusion until the patient is brought to the Emergency Department. When early EMT efforts yield no response in a patient with a penetrating wound of the abdomen, continuance of resuscitation is futile. Patients resuscitated in the pre-hospital setting after penetrating wounds of the chest have the best chance and the resuscitative efforts should continue during the short transport to the Emergency Department although hypotension persists. Even in this setting, however, long-term success is very limited.[6,7,8,9]

EMERGENCY DEPARTMENT RESUSCITATION

The next decision regarding the continuance of resuscitation occurs within the Emergency Department. Following the same guidelines which were initiated in the pre-hospital setting, the continuation of CPR in a patient without spontaneous cardiac activity after blunt injury is futile and all efforts should be discontinued. Likewise, when the combination of ventilation, external cardiac massage and intravenous fluids produces no spontaneous peripheral circulation following a penetrating wound of the abdomen, the resuscitation effort should be discontinued. When the combination of ventilation, external cardiac massage and the rapid intravenous infusion of crystalloid solution restores a peripheral pulse in a patient with a penetrating abdominal wound, the patient is a candidate for an Emergency Department thoracotomy or a five-minute transport to the operating room for thoracotomy and clamping of the descending aorta just above the diaphragm.[10,11] When occlusion of the thoracic aorta brings about a spontaneous restoration of pressure in the upper extremities, the patient, if not already in the operating room, should be transferred

rapidly to the operating room for laparotomy. Following entrance into the abdomen, the abdominal aorta should be secured or compressed under the diaphragm and efforts should be made to rapidly control the source of massive bleeding. When cross clamping of the thoracic aorta does not restore pressure in the upper extremities, further efforts at resuscitation will fail and the resuscitation effort should cease. This is true in either the Emergency Department or the operating room.

The greatest likelihood for successful CPR utilizing the triad of ventilation, external cardiac massage and intravenous fluid administration occurs in the patient with a penetrating chest wound. The institution of Emergency Department thoracotomy with pericardiotomy and release of a cardiac tamponade can be most dramatic. When the Emergency Department resuscitation room is fully equipped and prepared for such events, a single cardiorrhaphy suture may be placed at that time prior to transfer to the operating room for definitive completion of the operation. Alternatively, a finger may be held gently over the cardiac perforation while the patient is transferred to the operating suite for definitive cardiorrhaphy and completion of the operation. Similar results can be obtained in patients bleeding from partial severance of an intercostal artery or an internal mammary artery which can be contained during transport to the operating room by digital pressure placed on the bleeding artery from within the open thorax.[7,12]

OPERATING ROOM RESUSCITATION

The surgical team working with their anesthesia colleagues face difficult choices regarding resuscitation when attempting to control bleeding from multiple sites in a patient who is requiring many transfusions and several liters of balanced electrolyte solutions. This patient population would include those who responded to an Emergency Department thoracostomy prior to being rushed to the operating room for definitive therapy. Most of these patients have penetrating wounds. As indicated above, the hypotensive patient with a penetrating abdominal wound should have a left thoracotomy with cross clamping of the thoracic aorta just above the diaphragm followed by laparotomy when the systolic pressure exceeds 100 torr. Following the evacuation and tamponade of ongoing intraperitoneal bleeding, the surgeon must control large vessel bleeding before removing the thoracic aortic clamp, as the abdo-minal aorta is controlled first at a subdiaphragmatic location and then at a point just above the hemorrhaging visceral artery. Many patients by this time are developing coagulopathy and, therefore, require replacement therapy. Despite the development of coagulopathy, the implementation of the abdominal pack will not be useful until large open vessels have been controlled either by primary repair or by ligation. When large open vessels have been controlled so that continuing bleeding is due to coagulopathy, the abdomen can be packed open and the proximal aortic clamp removed. When removal of the aortic clamps cannot be achieved, a fatal outcome is expected and the resuscitative efforts can be abandoned. When pressure is sustained after removal of the aortic clamp and large vessels have been controlled, the coagulopathic bleeding from soft tissues and from injured liver and spleen can be contained by the pack technique. The patient is then transferred to the Surgical Intensive Care Unit (SICU) for continued resuscitation. This has been called "Damage Control."[2]

The decision to pack the abdomen and transfer to the SICU for continuance of resuscitation and correction of metabolic derangements is commonly made in patients who have not had to undergo thoracotomy for proximal control of the thoracic aorta. Most of these patients have sustained multiple penetrating wounds, an extensive blunt injury to the liver or a grade V pelvic fracture with bleeding into both the retroperitoneal and intraperitoneal spaces. The surgical and anesthesia teams must work closely to implement continuing resuscitation and correction of hypothermia, acidosis and coagulopathy as long as the patient remains in the operating room. The routine administration of fresh frozen plasma (FFP) and platelets slows the development of coagulopathy. The authors recommend that FFP supplementation be initiated when a patient is about to receive a sixth blood transfusion and bleeding is not yet controlled. Continued administration of FFP should be at a rate of two units for every six blood transfusions or in larger amounts whenever an identified coagulopathy is determined by prolongation of the prothrombin time or partial thromboplastin time.[13] The use of supplemental platelet transfusion will not be needed in patients who do not require at least ten blood transfusions. Before the onset

of clinical oozing, there often is an aroma emanating from the intestines which is unpleasant even though the intestines look quite viable but edematous. Once the surgeon perceives this unusual aroma, prediction of uncontrollable oozing is eminent; large vessels must be rapidly contained and Damage Control initiated. The continued resuscitative efforts can then take place in the SICU.[2,14,15,16,17]

SICU RESUSCITATION

Damage Control was first used over 40 years ago at the Detroit Receiving Hospital. Most patients treated in this manner had sustained either severe liver injuries from blunt trauma or rifle wounds, or had sustained major pelvic fractures with a combination of both intraperitoneal and retroperitoneal hemorrhage. This type of therapy was instituted because experienced surgeons recognized that continued efforts to control bleeding in the operating room was uniformly fatal.[18] One of the first patients treated with intraabdominal packing in the absence of a liver injury or pelvic fracture was operated upon by Dr. Alex Walt who packed a right retroperitoneal injury from a shotgun wound; at re-operation by the author (CEL) 18 hours later, all oozing had ceased, whereas two small arterial pumpers in the right retroperitoneal muscular were easily controlled by suture ligature. This patient recovered without incident. The key to success is knowing when to initiate packing and when to return to the operating room after successful restoration of volume, acid base balance and the coagulation status.[19] Patients without significant comorbid factors as outlined below should be treated very aggressively without regard to the number of blood products used to achieve successful restoration prior to re-operation. Prospective multifactor analyses in over 360 patients who received a minimal of eight blood transfusions and survived beyond the operation show that the likelihood for complete recovery is 63 percent when more than 25 blood products have been administered, 48 percent when more than 50 blood products have been administered, 26 percent when more than 75 blood products have been administered and 18 percent when more than 100 blood products have been administered during the intraoperative and postoperative resuscitation. Key elements to successful SICU resuscitation include volume expansion to restore perfusion pressure and urine flow without vasopressors and diuretics. Once these objectives are reached, the patient can be reoperated upon with removal of packs and appropriate hemostasis. Sometimes this sequence may be repeated as many as four times in order to reach the point where the packs can be removed and bleeding controlled. When multiple operations are necessary to reach this endpoint, the patient will almost always have severe respiratory failure and should have a tracheostomy performed at the second operative attempt or certainly by the third operative attempt.[2,3,6,20,21]

RESUSCITATION DURING MULTIPLE ORGAN FAILURE

The greatest cognitive challenge regarding the decision to continue resuscitation involves the critically ill SICU patient with combined compromise of pulmonary, cardiac, hepatic, and renal function with extensive expansion of the interstitial fluid space and with coagulopathy. Each organ responds differently to the overall insult and treatment has to be adjusted accordingly. Fortunately, in previously healthy patients, each organ insult will respond to treatment but there are certain exceptions.[22,23]

Patients with brain injury respond differently according to etiology. When the brain injury is caused by head trauma and is associated with intracranial bleeding, the response will be determined by the ability to correct the space occupying lesion. When operative intervention will provide no help in this situation and the patient continues to have impaired function beyond the fluid mobilization phase of hemorrhage shock, the likelihood for long-term improvement is dismal. The concomitant documentation of elevated intracranial pressure or a reduced cerebral blood flow will confirm the hopelessness of brain recovery and resuscitation can be discontinued. There are, however, isolated examples where partial craniectomy has allowed the patient with severe brain injury to survive beyond the mobilization phase without a lethal elevation intracerebral pressure and ultimately have a good outcome.[24,25]

Most previously healthy patients who survive the hemorrhage insult and develop combined cardiopulmonary failure will respond to resuscitative efforts including long-term ventilatory support and support of the cardiovascular system with inotropic agents and vasoactive

agents. When the cardiovascular insult persists or progresses to the point where some type of artificial means of oxygenation and perfusion such as Extra Corporeal Membrane Oxygenation (ECMO) needs to be instituted, the likelihood for survival in the adult patient is essentially zero. Whenever the severely injured adult patient needs ECMO, survival is negligible and resuscitation efforts can cease.

Maintenance of renal function during resuscitation must take the highest priority even at the expense of pulmonary function. When the severely injured patient develops acute oliguria, renal failure or renal shutdown, the chances for survival, despite the implementation of hemodialysis, are negligible. Consequently, one should use antimicrobials which do not adversely affect renal function. The development of the non-oliguric form of renal failure is compatible with survival and all resuscitative efforts should be continued, although nephrotoxic agents should be vigorously avoided.[26]

Hepatic dysfunction is a common occurrence following severe hemorrhage shock or severe sepsis. The altered hepatocyte function is recognized by the development of jaundice which will usually be about 50 percent conjugated bilirubin. Many patients with severe hemorrhage shock and subsequent sepsis may have bilirubin levels which exceed 30 ml/dl. Supportive therapy should include the avoidance of any hepatotoxic agents. As the other organ functions improve, the hepatic dysfunction will gradually resolve.[27]

COMORBID CONDITIONS AND CONTINUED RESUSCITATION

Age is an important determinate in the ultimate result of patients requiring extensive and prolonged resuscitation. The likelihood for failure significantly rises in patients over the age of 60 years and becomes extremely high in patients over 70 years. The surgeon, however, should assess the patient's physiologic age rather than calendar years. This is a judgment that must be made at the bedside, recognizing that the patient who is physiologically advanced in years is unlikely to survive a long episode of multiple organ failure.

Other comorbidities affect survival

Continued aggressive resuscitation in patients with advanced cancer or in a patient with other debilitating diseases is unwarranted. The general philosophy to follow in this circumstance is that the resuscitation should be continued in a manner compatible with the surgeon's own wishes if he/she were the patient. This general philosophy, of course, may be applied to all decisions regarding the continuance of resuscitation.

BIBLIOGRAPHY

1. *Cera SM, Mostafa G, Sing RF, et al: Physiologic predictors of survival of post-traumatic arrest. Am Surg 2003;69: 140-144.*

2. *Cosgriff N, Moore EE, Sauaia A, et al: Predicting life-threatening coagulopathy in massively transfused trauma patient. J Trauma 1997;42:857-862.*

3. *Lucas CE, Ledgerwood AM: Physiology of colloid-supplemented resuscitation from shock. J Trauma 2003;54:75-81.*

4. *Hoyt DB: Editorial. Prehospital care: Do not harm? Ann Surg 2003;237:161-162.*

5. *Hopson LR, Hirsh E, Delgado J, et al: Guidelines for withholding or termination of resuscitation in prehospital traumatic cardiopulmonary arrest: Joint position statement of the National Association of EMS Physicians and the American College of Surgeons Committee on Trauma. J Am Coll Surg 2003;196:106-112.*

6. *Berger S, Schwarz M, Huth R: Hypertonic saline solution and decompressive craniectomy for treatment of intracranial hypertension in pediatric severe traumatic brain injury. J Trauma 2002;53:568-563.*

7. *Blake DP, Gisbert VL, Ney AL, et al: Survival after emergency department versus operating room thoracotomy for penetrating cardiac injuries. Am Surg 1992;58:329-333.*

8. *Coats TJ, Keogh Se, Clark H, et al: Prehospital resuscitative thoracotomy for cardiac arrest after penetrating trauma: Rationale and case series. J Trauma 2001;50:670-673.*

9. *Liberman M, Mulder D, Lavoie A: Multicenter Canadian study of prehospital trauma care. Ann Surg 2003;237:153-160.*

10. Lewis G, Knottenbelt JD: Should emergency room thoracotomy be reserved for cases of cardiac tamponade? Injury 1991;22:5-6.

11. Rhee PM, Acosta J, Bridgeman A, et al: Survival of emergency department thoracotomy: Review of published data from the past 25 years. J Am Coll Surg 2000;190:288-198.

12. The National Association of EMS Physicians (NAEMSP) Standards and Clinical Practice Committee and the American College of Surgeons Committee on Trauma. J Am Coll Surg 2003;196:475-481.

13. Ledgerwood AM, Lucas CE: A review of studies on the effects of hemorrhagic shock and resuscitation on the coagulation profile. J Trauma 2003;54:S68-S74.

14. MacLeod JBA, Lynn M, McKenney MG, et al: Early coagulopathy predicts mortality in trauma. J Trauma 2003;55: 39-44.

15. Malone DL, Dunne J, Tracy JK, et al: Blood transfusion, independent of shock severity, is associated with worse outcome in trauma. J Trauma 2003;54:898-907.

16. Moore FA, Moore EE, Sauaia A, et al: An independent risk factor for postinjury multiple organ failure. Arch Surg 1997;132:620-625.

17. Varicoda EY, Figueiredo LF, Cruz RJ, et al: Blood loss after fluid resuscitation with isotonic or hypertonic saline for the initial treatment of uncontrolled hemorrhage induced by spleen rupture. J Trauma 2003;55:112-117.

18. Shapiro MB, Jenkins DH, Schwab CW, et al: Damage control: Collective review. J Trauma 2000;49:969-978.

19. Johnson JW, Gracia VH, Schwab CW, et al: Evolution in damage control for exsanguinating penetrating abdominal injury. J Trauma 2001;51:261-271.

20. Kushimoto S, Arai M, Aiboshi J, et al: The role of interventional radiology in patients requiring damage control laparotomy. J Trauma 2003;54:171-176.

21. Lucas CE: The water of life: A century of confusion. J Am Coll Surg 2001;192:86-93.

22. Cryer HG, Leong K, McArthur DL, et al: Multiple Organ Failure: By the time you predict it, it's already there. J Trauma 1999;46:597-606.

23. Moore FA, Sauaia A, Moore EE, et al: Postinjury multiple organ failure. J Trauma 1996;40:501-512.

24. Rudehill A, Bellander BM, Weitzbeg E, et al: Outcome of traumatic brain injuries in 1,508 patients: Impact of prehospital care. J Neurotrauma 2002;19:855-868.

25. Soukiasian HJ, Hui T, Avital I, et al: Decompressive craniectomy in trauma patients with severe brain injury. Am Surg 2002;68:1066-1071.

26. Tran DD, Cuesta MA, Van Leeuwen AM, et al: Risk factors for multiple organ system failure and death in critically injured patients. Surgery 1993;114:21-30.

27. Eddy VA, Morris JA, Cullinane DC: Hypothermia, coagulopathy, and acidosis. Surg Clin North Am 2000;80:845-855.

¿EVITA LA TORACOSCOPIA LA REALIZACIÓN DE TORACOTOMÍAS EN EL PACIENTE CON TRAUMA DE TÓRAX?

Carlos H. Morales, MD, MSc

RESUMEN

La cirugía toracoscópica asistida con video tiene un papel establecido como estudio diagnóstico y como tratamiento en el paciente con trauma de tórax. Con ella se evitan las toracotomías convencionales en los momentos que siguen al trauma o en el manejo de sus complicaciones. Como método de diagnóstico, sus principales aplicaciones son la evaluación de las heridas del diafragma y cardíacas y del sangrado continuo. Como tratamiento, se usa en el drenaje de hemotórax coagulado y de empiemas, en decorticaciones pleurales y para corregir fístulas broncopleurales postraumáticas.

Palabras clave

Trauma, Toracoscopia, Trauma de tórax

SUMMARY

Video assisted thoracoscopy surgery has a role as a diagnostic and therapeutic tool in patients with thoracic trauma. In trauma and traumatic complications this procedure avoids conventional thoracotomies. As a diagnostic method, it allows continuous bleeding, diaphragmatic and cardiac injuriy evaluation. As a therapeutic tool it is useful in empyemas and coagulated hemothorax, pleural decortication and also for bronchopleural fistula management.

Keywords

Trauma, VATS, Thoracoscopy, Thoracic trauma

Profesor Titular, Departmento de Cirugía, Universidad de Antioquia. Hospital San Vicente de Paúl

La evaluación endoscópica de las cavidades torácica y abdominal —toracoscopia y laparoscopia— se ha realizados desde principios del siglo XX, pero sus aplicaciones en trauma datan de la segunda mitad del siglo. En el pasado el cirujano general y el cirujano de trauma prefirieron la exploración abierta de las cavidades como método diagnóstico y terapéutico. La introducción de la colecistectomía laparoscópica y posteriormente el desarrollo tecnológico acelerado del método endoscópico han renovado el interés y la aceptación de la cirugía endoscópica entre los cirujanos generales y han estimulado su uso y la investigación sobre su papel en el paciente traumatizado.

El procedimiento de la toracoscopia —endoscopia de la cavidad torácica— fue descrito por primera vez en Alemania por George Kelling, quien utilizó un cistoscopio para la exploración de las cavidades pleural y peritoneal en perros. El procedimiento en humanos fue desarrollado por Hans Christian Jacobeus en 1910, quien practicó liberación de adherencias pleurales y colapso pulmonar como tratamiento de la tuberculosis pulmonar. La aplicación de la toracoscopia en trauma solo aparece en 1946 cuando J. Branco describió su uso exitoso en cinco pacientes en quienes evitó una toracotomía, haciendo control de vasos sangrantes con electrocoagulación por vía toracoscópica.[1] Posteriormente, Jackson y Ferreira[2] precisaron el papel de la toracoscopia en el diagnóstico de heridas de diafragma y J. Jones[3] presentó su papel en el diagnóstico y tratamiento de pacientes con trauma torácico penetrante. Sin embargo, sólo fue en los inicios de la década del 90, luego de los avances técnicos, cuando se popularizó su uso y se llevó a la toracoscopia y la cirugía torácica videoasistida a ocupar en el nuevo siglo un lugar bien definido en la atención del paciente traumatizado.

A medida que crecen el entusiasmo y entrenamiento de los cirujanos de trauma en las técnicas toracoscópicas han aumentado sus indicaciones diagnósticas y terapéuticas. En general está indicada en pacientes hemodinámicamente estables, en quienes la realización del procedimiento no implique riesgos. No son candidatos a ella los pacientes que no pueden tolerar la ventilación limitada a un pulmón y los hemodinámicamente inestables.

APLICACIONES DE LA TORACOSCOPIA EN TRAUMA

La técnica de evaluación endoscópica de la cavidad pleural tiene varias indicaciones; algunas de ellas se deben realizar en los momentos siguientes al trauma (situaciones agudas) y otras se llevan a cabo de manera diferida o como manejo de complicaciones del trauma.

Diagnóstico y control de la hemorragia

Los pacientes estables hemodinámicamente pero con sangrado continuo por el tubo de toracostomía y que no tienen indicación de toracotomía urgente (drenaje mayor de 1.500 ml o 200 ml/hora) se pueden someter a una evaluación toracoscópica. Es posible identificar fuentes de sangrado susceptibles de control con grapas o electrocauterio como las que se originan en la arteria mamaria interna o las intercostales. Sangrados originados en laceraciones pulmonares se pueden controlar con suturas mecánicas. Si el volumen de la hemorragia no permite ver su origen o cuando no es posible un rápido control del vaso se debe hacer una conversión inmediata a cirugía abierta[2, 4, 5] (Véase figura1).

Situaciones agudas
— Diagnóstico y control de hemorragia. — Diagnóstico de heridas del diafragma. — Diagnóstico de heridas del corazón. — Evaluación de lesiones mediastinales.
Situaciones diferidas y manejo de complicaciones
— Tratamiento del hemotórax coagulado. — Tratamiento del empiema. — Tratamiento de las fístulas broncopleurales postraumáticas. — Extracción de cuerpos extraños.

Figura 1 - Indicaciones de la toracoscopia en trauma.

Heridas del diafragma

Los pacientes con heridas torácicas bajas o en la topografía toracoabdominal por arma blanca o arma de fuego y que no tienen indicación quirúrgica inmediata se pueden investigar mediante toracoscopia. Diferentes autores han puesto de manifiesto las ventajas de este método: fácil realización, seguridad, invasión mínima, sensibilidad del 100%, especificidad del 97% y precisión del 98%.[6-8] Se ha descrito igualmente el papel de la laparoscopia en el diagnóstico del trauma toracoabdominal penetrante. La sensibilidad del método es del 83% y la especificidad, del 100%.[9-10] Las características operativas de estos procedimientos son superiores a las de otros estudios diagnósticos excepto en la evaluación de lesiones de la región toracoabdominal izquierda por arma cortopunzantes en las cuales se ha propuesto la exploración digital con anestesia local en la sala de atención de urgencias con un excelente desempeño (sensibilidad del 96%, especificidad del 83,3%, valor predictivo positivo del 91%, valor predictivo negativo del 93,7%).[11] No se debe establecer una controversia sobre cuál procedimiento practicar, laparoscopia o toracoscopia, para descartar heridas de diafragma en pacientes estables. Ambos tienen ventajas y desventajas. La toracoscopia permite una excelente evaluación del receso posterior que no es evaluable por laparoscopia, evita un procedimiento abdominal si la exploración es negativa y permite la evaluación de otras estructuras torácicas y la evacuación del hemotórax cuando está presente. La laparoscopia tiene las ventajas de evaluar otras lesiones abdominales y evitar un tubo de toracostomía cuando no hay indicación para su uso. El cirujano de trauma debe estar entrenado en la ejecución de ambos procedimientos y tener el buen juicio de definir cuál de ellos se debe realizar en un paciente en particular. En general, se debe practicar toracoscopia en lesiones por arma blanca posteriores o laterales en la topografía toracoabdominal y en las anteriores con presencia de hemotórax y/o neumotórax en quienes no es posible demostrar la lesión del diafragma o su ausencia mediante la exploración digital de la herida traumática. La lapa-

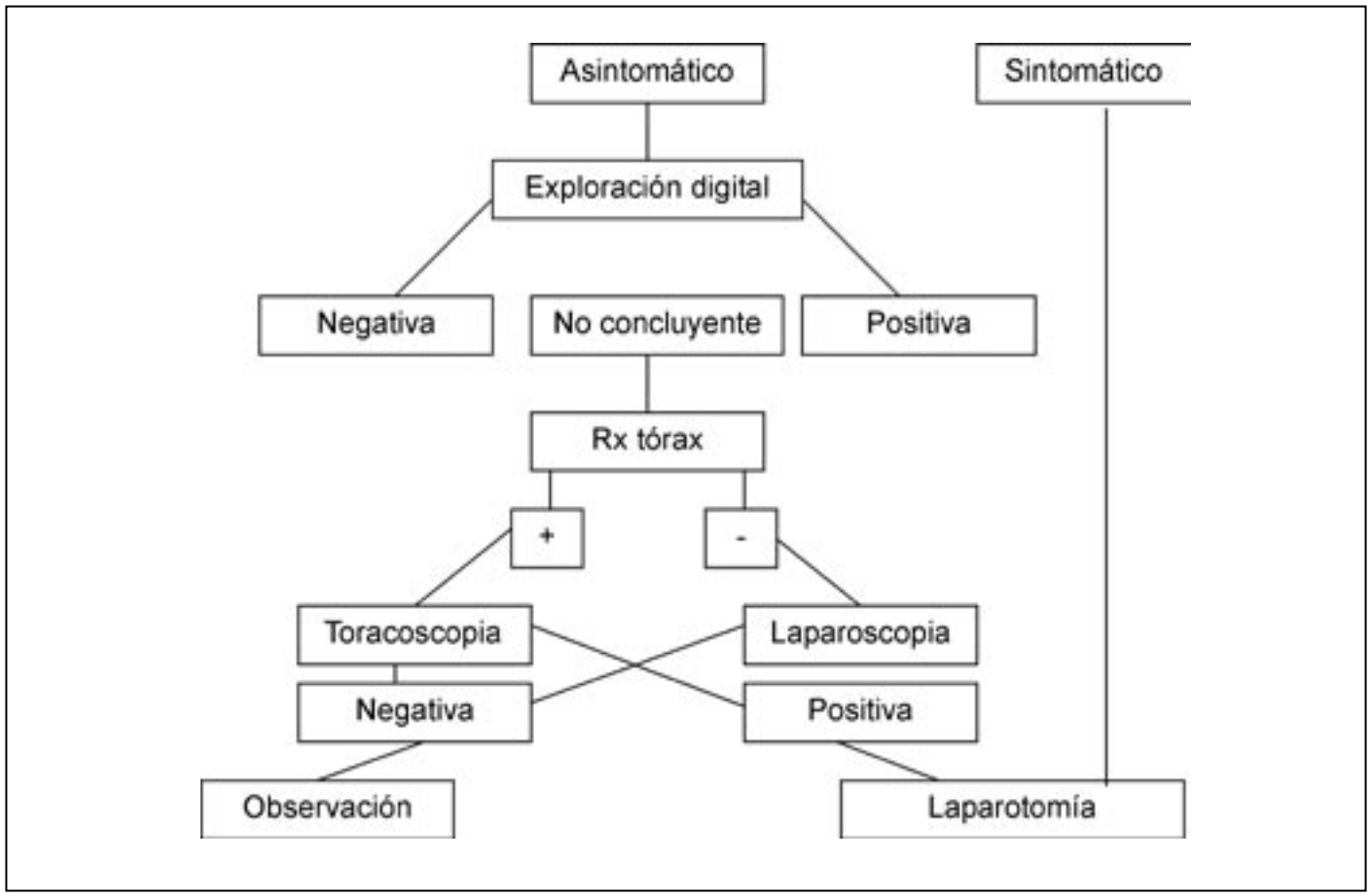


Figura 2 - Flujo de actividades diagnósticas en lesiones por arma cortopunzante en la topografía toracoabdominal.

roscopia se indica en las lesiones anteriores y laterales sin hemotórax o neumotórax asociados. En la figura 2 se presenta el flujograma de actividades que se sigue en el Hospital Universitario San Vicente de Paúl, de Medellín-Colombia, para la evaluación de los pacientes con lesiones toracoabdominales izquierdas por arma cortopunzante. Las heridas del hemidiafragma derecho por arma cortopunzante no constituyen un problema mayor pues no se han reportado casos de encarcelación tardía a través de ellas de una víscera hueca[12] debido probablemente a la interposición del hígado; además, la herniación del hígado a través de pequeños defectos es poco probable.[13]

La evaluación endoscópica de la cavidad torácica ha demostrado también ser de gran utilidad para la evaluación del diafragma en pacientes con lesiones por arma de fuego en la topografía toracoabdominal.[6,7] En la figura 3 se presenta el flujograma de actividades para seguir en los pacientes con dichas lesiones y sin indicación de laparotomía inmediata. Freeman y colaboradores,[14] en la serie más larga publicada de pacientes sometidos a toracoscopia para evaluación de heridas de diafragma, presentan una serie de factores de riesgo clínicos e imaginológicos asociados con la presencia de lesión: radiografía de tórax anormal, lesiones abdominales asociadas, lesiones por proyectiles de alta velocidad, orificio de entrada por debajo de la tetilla o la escápula y orificio de entrada al lado derecho.

Por otra parte, la cirugía torácica videoasistida ha permitido el reparo de heridas del diafragma de varias horas de evolución en pacientes en quienes el cuadro

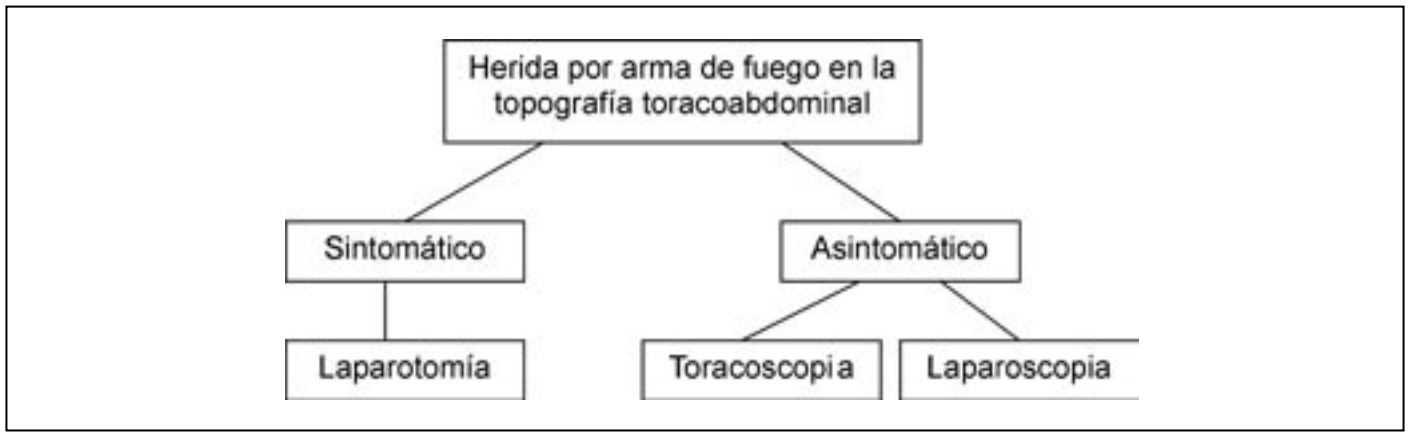


Figura 3 - Flujo de actividades en heridas por arma de fuego en la topografía toracoabdominal.

clínico permite asumir ausencia de lesión visceral abdominal.[15]

Diagnóstico de las heridas del corazón

Aproximadamente un 20% de los pacientes con heridas cardíacas no tienen signos o síntomas de su lesión.[16] En este grupo de pacientes se han utilizado diversos estudios que pretenden demostrar la presencia de sangre en la cavidad pericárdica. La pericardiocentesis no está indicada en el paciente estable hemodinámicamente; la radiografía simple de tórax y el electrocardiograma no descartan la lesión. Le ecocardiografía es el estudio no invasivo más importante en el diagnóstico de heridas cardíacas; sin embargo, su utilidad es limitada, en primer lugar, por el acceso al equipo y la necesidad de tener disponible un cardiólogo especializado disponible y, en segundo lugar, porque la sensibilidad del método disminuye en presencia de enfisema subcutáneo, tubos de toracostomía, hemotórax y lesiones de la pared[17,18] Más recientemente Rozycki y colaboradores[19] demostraron, con un trabajo multiinstitucional, que el ultrasonido convencional con ventana subxifoidea realizado en el departamento de urgencias debe ser el procedimiento diagnóstico inicial en los pacientes con sospecha de herida cardíaca asintomáticos o con síntomas menores (sensibilidad del 100%, especificidad del 96,9% y precisión del 97,3%). La ventana pericárdica subxifoidea tiene altas sensibilidad y especificidad (100% y 96%, respectivamente).[20, 21] En el Hospital Universitario San Vicente de Paúl, de Medellín-Colombia, en un período de 55 meses (septiembre de 1991 a febrero de 1996) se practicaron 108 ventanas pericárdicas por toracoscopia y 33 fueron positivas para sangre (30,6%). El método tuvo una sensibilidad del 100% y especificidad del 96% con las ventajas adicionales de que permitía evaluar otras estructuras torácicas y evacuar el hemotórax asociado, cuando estaba presente, razones que nos han llevado a recomendar la toracoscopia como método de diagnóstico de las heridas cardíacas con síntomas menores o sin ellos cuando otros estudios no invasivos no son concluyentes o no se encuentran disponibles.[22] (Véase figura 4)

Evaluación de las lesiones mediastinales

La toracoscopia puede ser de gran utilidad en la evaluación de las estructuras mediastinales cuando otros estudios no invasivos no han permitido hacer el diagnóstico o cuando no están disponibles.[23]

Tratamiento del hemotórax coagulado

La gran mayoría de los pacientes con hemotórax postraumático se tratan con éxito con una sonda de toracostomía; pero entre el 5 y el 30% de ellos pueden desarrollar un hemotórax coagulado[24] que si no se drena, puede inducir la formación de fibrotórax y atrapamiento pulmonar.[25, 26]

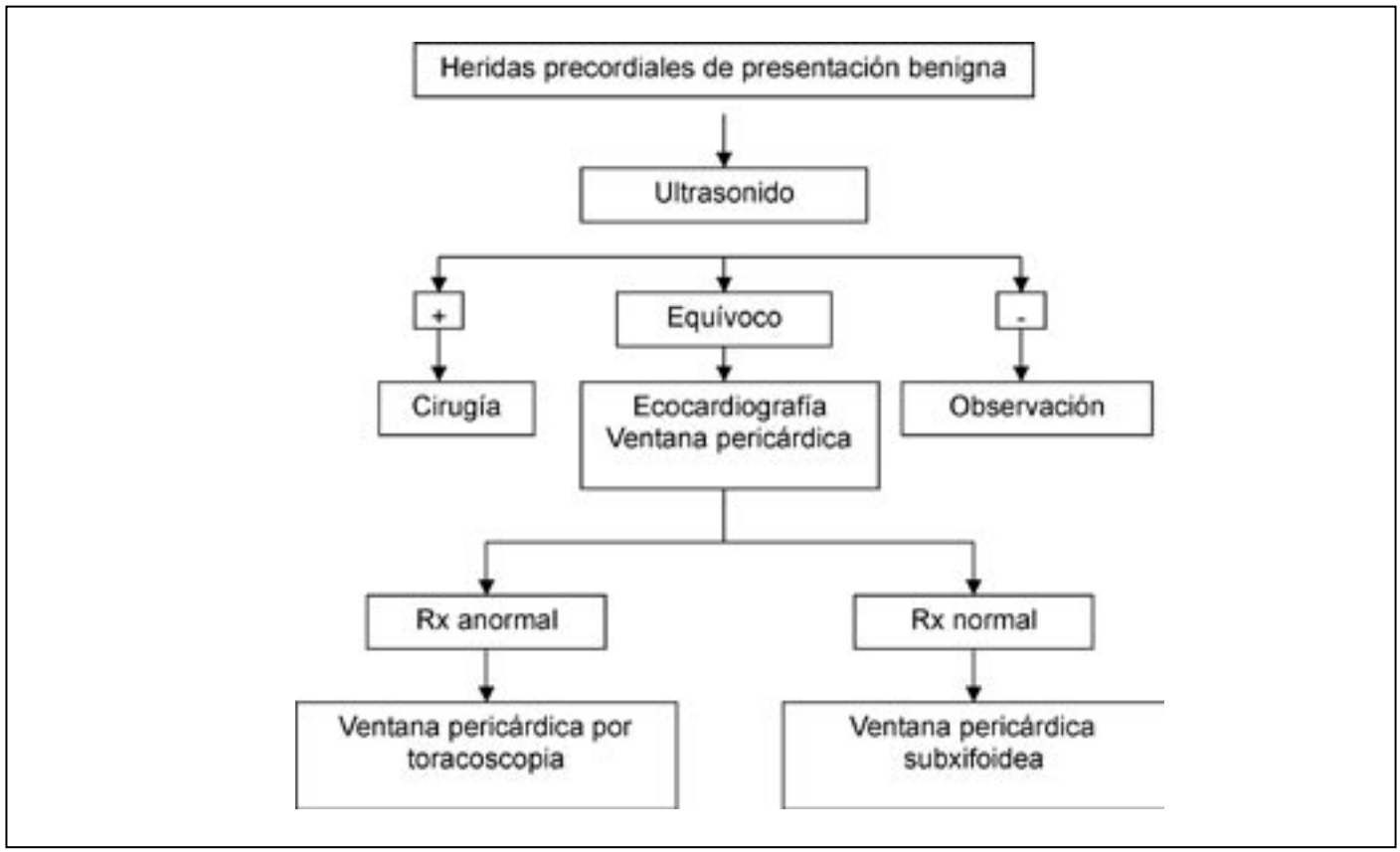


Figura 4 - Flujo de actividades diagnósticas en pacientes con lesiones precordiales de presentación benigna.

El tratamiento tradicional del hemotórax coagulado ha sido la toracotomía, pero ahora se recomienda la toracoscopia como tratamiento de primera línea, dejando la toracotomía como una alternativa, cuando con la primera no se logra evacuar los coágulos y no se consigue la reexpansión pulmonar. Diversos trabajos han comprobado la seguridad y eficacia de la toracoscopia para el tratamiento de esta complicación postraumática.[27]

Por años, la radiografía simple de tórax se ha utilizado para el diagnóstico de esta complicación. Sin embargo, este método no se puede utilizar de manera confiable para la selección de todos los pacientes que requieren intervención quirúrgica y en muchos de ellos la decisión se debe apoyar en los hallazgos de la tomografía computarizada.[28]

No se ha definido completamente el tiempo entre el diagnóstico del hemotórax coagulado y el drenaje por toracoscopia en el cual se presente el menor número de complicaciones y los resultados sean altamente satisfactorios. Diferentes estudios han demostrado que la evacuación temprana disminuye las complicaciones como el empiema y el fibrotórax.[25,29] Algunos autores recomiendan la evacuación en los tres días siguientes al trauma,[30] pero otros reportan éxito cuando el procedimiento se realiza hasta los 7 días postrauma.[31-34] En una evaluación prospectiva en el Hospital San Vicente de Paúl, de Medellín-Colombia, de 61 pacientes consecutivos con diagnóstico de hemotórax coagulado postraumático que fue drenado por toracoscopia se encontró que después del séptimo día del trauma el porcentaje de conversión a toracotomía es mayor. El tiempo transcurrido entre el momento del trauma y la

toracoscopia se comportó como un factor importante relacionado con la presencia de complicaciones y la conversión a toracotomía aunque no fue estadísticamente significativo.[35]

El drenaje por toracoscopia del hemotórax coagulado, o retenido, es una de las principales indicaciones del método endoscópico en el paciente traumatizado. Con los avances tecnológicos, la introducción del video y el perfeccionamiento del instrumental utilizado, esta técnica se ha consolidado como un procedimiento seguro, sencillo y eficiente para el tratamiento del hemotórax coagulado postraumático.[27]

Tratamiento del empiema

Otra aplicación terapéutica de la cirugía torácica videoasistida es la evacuación de empiemas postraumáticos, acompañada de decorticación de la pleura parietal. Diversas publicaciones apoyan esta indicación.[5, 31, 36-38] El porcentaje de éxito reportado es del 86%.[27] Se debe anticipar la conversión a cirugía abierta considerando el tiempo de evolución y los hallazgos imaginológicos.

Tratamiento de las fístulas broncopleurales postraumáticas

Tradicionalmente el neumotórax postraumático persistente luego del trauma torácico ha sido manejado con éxito mediante succión permanente por el tubo de toracostomía; pero algunos pacientes requieren tratamiento quirúrgico. Schermer y colaboradores[39] estudiaron 39 pacientes con fístula broncopleural postraumática mayor de 3 días. A 25 de ellos les practicaron cirugía torácica videoasistida y a los otros 14, tratamiento no quirúrgico; demostraron que con la cirugía de invasión mínima se reducen el número de días con tubo de toracostomía y la estancia hospitalaria.

La cirugía torácica videoasistida es ahora una excelente alternativa a la cirugía abierta convencional; es posible practicar por este método resecciones pulmonares segmentarias con suturas mecánicas, aplicar parches de fibrina en las lesiones pulmonares o realizar pleurectomías con buenos resultados y con los beneficios adicionales de la cirugía de invasión mínima.[40]

Extracción de cuerpos extraños

Con alguna frecuencia fue necesario en el pasado realizar grandes incisiones para extraer cuerpos extraños de la cavidad pleural o la pericárdica con la consiguiente morbilidad que esto implica; sin embargo, con la práctica cada vez más frecuente de procedimientos endoscópicos esto es posible con una invasión menor según lo confirman diferentes reportes.[41-43]

Otras aplicaciones

La toracoscopia tiene otra serie de aplicaciones en pacientes con complicaciones derivadas del trauma tales como ligadura del conducto torácico en pacientes con quilotórax postraumático que no mejoró con tratamiento médico,[44] corrección de hernias diafragmáticas postraumáticas,[45] resección de fragmentos óseos que producen dolor secundario a fracturas costales[46] y el lavado asistido de la cavidad pleural contaminada en las lesiones toracoabdominales con lesión de víscera hueca.[47]

BIBLIOGRAFÍA

1. *Branco J MC. Thoracoscopy as a method of exploration in penetrating injuries of the chest. Dis Chest 1946; 12: 330.*

2. *Jackson AM, Ferreira AA. Thoracoscopy as an aid to the diagnosis of diaphragmatic injury in penetrating wounds of the lower chest: a preliminary report. Injury 1976; 7: 213-217.*

3. *Jones JW, Kitahama A, Webb WR, McSwain N. Emergency thoracoscopy: a logical approach to chest trauma management. J Trauma 1981; 21: 280-284.*

4. *Lang-Lazdunski L, Mouroux J, Pons F, Grosdidier G, Martinod E, Elkaim D, et al. Role of videothoracoscopy in chest trauma. Ann Thorac Surg 1997; 63: 327-333.*

5. *Liu DW, Liu HP, Lin PJ, Chang CH. Video-assisted thoracic surgery in treatment of chest trauma. J Trauma 1997; 42: 670-674.*

6. *Ochsner MG, Rozycki GS, Lucente F, Wherry DC, Champion HR. Prospective evaluation of thoracoscopy for diagnosing diaphragmatic injury in thoracoabdominal trauma: a preliminary report. J Trauma 1993; 34: 704-710.*

7. *Uribe RA, Pachón CE, Frame SB, Enderson BL, Escobar F, García GA. A prospective evaluation of thoracoscopy for the diagnosis of penetrating thoracoabdominal trauma. J Trauma 1994; 37: 650-654.*

8. *Martínez M, Briz JE, Carrillo EH. Video thoracoscopy expedites the diagnosis and treatment of penetrating diaphragmatic injuries. Surg Endosc 2001; 15: 28-32.*

9. *Ivatury RR, Simon RJ, Stahl WM. A critical evaluation of laparoscopy in penetrating abdominal trauma. J Trauma 1993; 34: 822-827.*

10. *Ertekin C, Onaran Y, Guloglu R, Gunay K, Taviloglu K. The use of laparoscopy as a primary diagnostic and therapeutic method in penetrating wounds of lower thoracal region. Surg Laparosc Endosc 1998; 8: 26-29.*

11. *Morales CH, Villegas MI, Ángel W, Vásquez JJ. Value of digital exploration for diagnosis of injuries to the left side of the diaphragm caused by stab wounds. Arch Surg 2001; 136: 1.131-1.135.*

12. *Madden MR, Paull DE, Finkelstein JL, Goodwin CW, Marzulli V, Yurt RW, et al. Occult diaphragmatic injury from stab wounds to the lower chest and abdomen. J Trauma 1989; 29: 292-298.*

13. *Feliciano DV, Cruse PA, Mattox KL, Bitondo CG, Burch JM, Noon GP, et al. Delayed diagnosis of injuries to the diaphragm after penetrating wounds. J Trauma 1988; 29: 1.135-1.144.*

14. *Freeman RK, Al Dossari G, Hutcheson KA, Huber L, Jessen ME, Meyer DM, et al. Indications for using video-assisted thoracoscopic surgery to diagnose diaphragmatic injuries after penetrating chest trauma. Ann Thorac Surg 2001; 72: 342-347.*

15. *Koehler RH, Smith RS. Toracoscopic repair of missed diaphragmatic injury in penetrating trauma: case report. J Trauma 1994; 36: 424-427.*

16. *Saadia R, Levy RD, Degiannis E, Velmahos GC. Penetrating cardiac injuries: clinical classification and managenet strategy. Br J Surg 1994; 81: 1.572-1.575.*

17. *Jiménez E, Martín M, Krukenkamp I, Barrett J. Subxiphoid pericardiotomy versus echocardiography: A prospective evaluation of the diagnosis of occult penetrating cardiac injury. Surgery 1990; 108: 676-679.*

18. *Meyer DM, Jessen ME, Greyburn PA. Use of echocardiography to detect occult cardiac injury after penetrating thoracic trauma: A prospective study. J Trauma 1995; 39: 902-907.*

19. *Rozycki GS, Feliciano DV, Ochsner G, Knudson MM, Hoyt D, Davis F, et al. The role of ultrasound in patients with possible penetrating cardiac wounds: A prospective multicenter study. J Trauma 1999; 46: 543-552.*

20. *Brewster SA, Thirlby RC, Snyder WH III. Subxyphoid pericardial window and penetrating cardiac trauma. Arch Surg 1988; 123: 937-946.*

21. *Andrade Alegre R, Mon L. Subxyphoid pericardial window in the diagnosis of penetrating cardiac trauma. Ann Thoracic Surg 1994; 58: 1.139-1.141.*

22. *Morales CH, Salinas CM, Henao CA, Patiño PA, Muñoz CM. Thoracoscopic pericardial window and penetrating cardiac trauma. J Trauma 1997; 42: 273-275.*

23. *Wong MS, Tsoi EK, Henderson VJ, Hiruela ER, Forest CT, Smith RS, et al. Videothoracoscopy: an effective method for evaluating and managing thoracic trauma patients. Surg Endosc 1996; 10: 118-121.*

24. *Eddy AC, Luna GK, Copaus M. Empiema thoracis in patients undergoing emergent closed tube thoracostomy for thoracic trauma. Am J Surg 1989; 157: 494-497.*

25. *Coselli JS, Mattox KL, Beall AC. Reevaluation of early evacuation of clotted hemothorax. Am J Surg 1984; 148: 786-790.*

26. *Mancini M, Smith LM, Nein A, Buechter KJ. Early evacuation of clotted blood in hemothorax using thoracoscopy. Case reports. J Trauma 1993; 34: 144-147.*

27. *Villavicencio RT, Aucar JA, Wall Jr MJ. Analysis of thoracoscoy in trauma. Surg Endosc 1999; 13: 3-9.*

28. *Velmahos GC, Demetriades D, Chan L, Tastevossian R, Cornwell EE, Yassa N, et al. Predicting the need for thoracoscopic evacuation of residual traumatic hemothorax: Chest radiograph is insufficient. J Trauma 1999; 46: 65-70.*

29. *Milfield DJ, Mattox KL, Beall AC Jr. Early evacuation of clotted hemothorax. Am J Surg 1978; 136: 686-692.*

30. *Vassiliu P, Velmahos GC, Toutouzas KG. Timing, safety and efficacy of thoracoscopic evacuation of undrained post-traumatic hemothorax. Am Surg 2001; 67: 1.165-1.169.*

31. *Heniford BT, Carrillo EH, Spain DA, Sosa JL, Fulton RB, Richardson JD. The role of thoracoscopy in the management of retained thoracic collections after trauma. Ann Thorac Surg 1997; 63: 940-943.*

32. *Carrillo Eh, Richardson JD. Thoracoscopy in the management of hemothorax and retained blood after trauma. Curr Opin Pulm Med 1998; 4: 243-246.*

33. *Abolhoda A, Livingston DH, Donahoo JS, Allen K. Diagnostic and therapeutic video assisted thoracic surgery (VATS) following chest trauma. Eur J Cardiothorac Surg 1997; 12: 356-360.*

34. *Ambrogi MC, Lucchi M, Dini P, Mussi A, Angeletti CA. Videothoracoscopy for evaluation and treatment of hemotórax. J Cardiovasc Surg 2002; 43: 109-112.*

35. *Villegas MI, Morales CH. Tratamiento del hemotórax coagulado mediante toracoscopia. Rev Colomb Cir 2000; 1: 29-31.*

36. *O·Brien J, Cohen M, Solit R, Lindenbaum G, Finnegan J, Vemick J. Thoracoscopic drainage and decortication as definitive treatment for empyema thoracis following penetrating chest injuty. J Trauma 1994; 36: 536-539.*

37. *Llie N. Functional effects of decortication after penetrating war injuries to the chest. J Thorac CardiOvasc Surg 1996; 111: 1.024-1.025.*

38. *Sherer LA, Battistella FD, Owings JT, Aguilar MM. Thoracoscopy for post-traumatic empyema. Arch Surg 1998; 133: 637-641.*

39. *Shermer CT, Matteson BD, Demarest III GB, Albrecht RM, Davis VH. A prospective evaluation of video-assisted thoracic surgery for persistent air leak due to trauma. Am J Surg 1999, 177: 480-484.*

40. *Carrillo EH, Schmacht DC, Gable DR, Spain DA, Richardson JD. Thoracoscopy in the management of posttraumatic persistent pneumothorax. J Am Coll Surg 1998; 186: 639-640.*

41. *Morales CH, Gómez F. Cuerpo extraño en el pericardio. Rev Colom Cir 1997; 12: 163-166.*

42. *Bar I, Rivkind A, Deeb M, Simha M. Thoracoscopically guided extraction of an embedded knife from the chest. J Trauma 1998; 44: 222-223.*

43. *Celkins CM, Moore EE, Jonson JL, Smith WR. Removal of an intrathoracic migrated fixation pin by thoracoscopy. Ann Thorac Surg 2001; 71: 368-370.*

44. *Buchan KG, Hosseinpour AR, Ritchie AJ. Thoracoscopic thoracic duct ligation for traumatic chylothorax. Ann Thorac Surg 2001; 72: 1.366-1.367.*

45. *Kamelgard JI, Harris L, Reardon MJ, Reardon PR. Thoracoscopic repair of a recurrent diaphragmatic hernia four years after initial trauma, laparotomy and repair. J Laparoendosc Adv Surg Teach A 1999; 9: 171-175.*

46. *Sing RF, Mostafa G, Matthews BD, Kercher KW. Thoracoscopic resection of painful multiple rib fractures: case report. J Trauma 2002; 92: 391-392.*

47. *Salinas CM, Isaza LF, Lenis G, Hernández S, Vásquez JJ. Lavado de la cavidad pleural en pacientes con heridas toracoabdominales. Comparación entre toracoscopia y toracotomía. Iatreia 1995; 8: 150-152.*

IMPLEMENTATION OF THE ADVANCED TRAUMA OPERATIVE MANAGEMENT COURSE

Lenworth M. Jacobs, MD, MPH, FACS, Karyl J. Burns, RN, PhD, Stephen Luk, MD, FACS, Ronald I. Gross, MD, FACS.

SUMMARY

Pelvic fractures are truly markers of injury severity. Mortality is considerably high in some situations, complications are expected and long term sequelae possible. The majority of patients sustain concomittant injuries, which definitively have an impact on outcome. Although hemorrhage remains a chief concern, it frequently results from associated injuries in combination with the pelvic fracture. External fixation and angiographic embolization are useful tools in managing the cases of pelvic exsanguination. Especially in patients with persistent shock, a multidisciplinary clinical pathway is mandatory to optimally take care of these patients. The understanding of pelvic anatomy, trauma mechanism and fracture classification enables a better comprehension of possible sites of bleeding and the risk of associated injuries. The knowledge of prognostic factors as well as the main causes of death facilitates the definition of priorities in the management of these patients. A thorough analysis of the methods to control pelvic hemorrhage allows the correct choice for each situation and institution. Finally, an algorithm for patients sustaining pelvic fractures and persistent shock is proposed, based on all ideas previously discussed.

Keywords

Trauma, Surgical education, Simulation, Education.

Department of Traumatology, University of Connecticut, Trauma Program at Hartford Hospital

RESUMEN

La reducción de oportunidades para adquirir habilidades quirúrgicas entre los cirujanos genera la necesidad de nuevos métodos educacionales. El curso ATOM (Advanced Trauma Operative Management), consistente en conferencias didácticas, experiencia operatoria en el laboratorio y un CD-ROM, suministra a los estudiantes una oportunidad para adquirir habilidades quirúrgicas en aquellas lesiones penetrantes de tórax y abdomen que son comunes, pero menos frecuentes. Los datos de los primeros cincuenta participantes del curso ATOM han demostrado claramente una ganancia sustancial en los conocimientos y eficacia al completar el curso. El curso ATOM es completamente replicable. Este articulo explica los fundamentos teóricos del curso y los detalles acerca de como se puede implementar el curso ATOM.

Palabras clave

Trauma, Educación Quirúrgica, Simulación, Educación.

The Advanced Trauma Operative Management Course (ATOM) was developed to respond to the need to train surgeons in the management of penetrating injuries to the chest and abdomen.[1] Historically, surgeons have always been expected to have the technical skills to surgically manage patients who have sustained penetrating injuries. The ability of a surgeon to rapidly control exsanguinating hemorrhage, manage severe injuries to solid organs in the chest and abdomen, and repair injuries to the viscera have been the hallmark of surgical competence.

Military conflicts have traditionally produced significant injuries that resulted in severe morbidity and mortality. Many surgeons received their formal training in the

management of penetrating injuries in the battlefield arena. Experience with all types and severity of major injuries became the educational standard in the major conflicts of the last century. The experience gained from these military conflicts was brought back to the civilian arena by these competent military surgeons. However, the decline of large-scale military conflicts in recent years has resulted in fewer training opportunities provided by the military.[1]

In the 1970s and 1980s the proliferation of violent crime in the United States was such that the majority of trauma training occurred in the major inner city hospitals and trauma centers. Penetrating injuries sustained by civilians in the inner cities became the new educational arena for trauma surgery.

In the decade of the 1990s there were considerable positive sociologic changes which resulted in a dramatic reduction in penetrating violent crime. This was coupled by more sophisticated diagnostic imaging techniques which allowed for selective management of blunt vehicular trauma. In addition to these two factors, the reduction in the duration of surgical training programs has further contributed to the decreased exposure of surgical residents to penetrating trauma.

In order to train surgeons who would be competent in the management of penetrating trauma and to retain the skills of surgeons who are required to manage injured patients in a suburban or rural hospital, it has become necessary to implement new educational methods. No longer can the education of surgeons rely solely on opportunities provided by injured patients. The education of surgeons must include structured opportunities to practice the repair of common but less frequently encountered penetrating injuries.

ATOM evolved from the Definitive Surgical Trauma Care course (DSCT). This DSTC was developed by a group of senior surgeons and the International Association for the Surgery of Trauma and Surgical Intensive Care in South Africa, Europe, Australia, and the United States.[1] An early version of the ATOM course was successfully implemented at Hartford Hospital in 2000 and served as the impetus for the present ATOM course.[2] The ATOM Course was created to provide opportunities for surgeons to engage in operative management of penetrating injuries. The course sharply focuses the cognitive body of knowledge relative to penetrating trauma and teaches the technical surgical operations to manage and repair injuries in the chest and abdomen. The purpose of this paper is to describe the ATOM course and how it can be implemented.

DESCRIPTION OF THE ATOM COURSE

The ATOM course begins by having the student review a CD-ROM of the management of penetrating injuries in the chest and abdomen. THE CD-ROM reviews the anatomical cadaver approaches to various structures. A number of case scenarios allow the learner to integrate the operative management strategies into clinical cases. Once the students have reviewed these cases, they are then given six lectures which are confined to the operative management of injuries to the chest, major vascular structures, the solid organs within the abdomen and the retroperitoneum and the diaphragm. The student is then taken to the operating room where large 50 kg swine are used for operative experiences. Clinical scenarios are given to the students that reflect real life trauma cases involving 14 penetrating injuries. The injuries are presented in Table 1. The surgical procedures of the ATOM course are presented in Table 2. Both the injuries and procedures were evaluated by a panel of expert traumatologists as being important for course content.[1]

In the laboratory the instructor creates a series of injuries while the student is out of the room. The student is then brought to the operating table to identify and manage these injuries. The student is asked to develop a competent treatment plan for each injury and then successfully demonstrate to the instructor one method of repairing the injury. The injuries become more severe and more difficult to repair as the operative experience continues. It is essential that the repairs are successfully completed and the animal is maintained in a stable state to the completion of all procedures. The animals are monitored in exactly the same way that the human would be monitored in the operating room. This realistic scenario creates the same visual, auditory, and mental cues that would alert the operating surgeon to a hemodynamically unstable situation in the human environment. The entire

TABLE 1 - PENETRATING INJURIES PRESENTED IN ATOM.

Small bowel enterotomies
Gastrotomies
Anterior and posterior
Diaphragmatic laceration
Splenic laceration
Inferior pole
Laceration of hilum
Laceration to the body of the pancreas
Renal laceration
Inferior pole
Laceration of hilum
Ureteral laceration
Inferior vena cava laceration
Duodenal injury
Hepatic laceration
Bladder laceration
Cardiac injury
Ventricular stab wound
Atrial stab wound

TABLE 2 - SURGICAL PROCEDURES PRESENTED IN ATOM.

Resection and ligation for small bowel enterotomies.
Two-layer closure for gastrotomies.
Running locked-stitch closure for gastrotomies.
Pyloric exclusion for gastrotomies.
Repair with simple interrupted stitches for diaphragm.
Check for pneumostasis indiaphragm laceration.
Pledgeted horizontal mattress repair for splenic laceration.
Splenectomy for splenic laceration.
Distal pancreatectomy for pancreatic laceration.
Ligation of splenic artery and vein for pancreatic laceration.
Control of renal artery and vein for renal laceration.
Pledgeted repair for renal laceration.
Nephrectomy for renal laceration.
Repair with running prolene stitch for inferior vena cava laceration.
Kocher maneuver for duodenal injury.
Two-layer repair for duodenal injury.
Primary repair with stent for ureteral laceration.
Finger fracture technique for hepatic laceration.
Cautery and suture repair forhepatic laceration.
Median sternotomy for cardiac injury.
Fingertip control of hemorrhage for right ventricular stab wound.
Foley catheter insertion for right ventricular stab wound.
Pledgeted suture/staple repair for right ventricular stab wound.
Control with vascular clamp for right atrial stab wound.

experience is designed to reproduce the tensions and stresses of managing a severely injured patient.

THEORETICAL FRAMEWORK

The ATOM course is grounded in social cognitive theory[3] and relies upon the construct of self-efficacy to guide teaching and evaluation activities. Self-efficacy is recognized as providing the "most comprehensive understanding of the interplay of cognition, affect and behavior."[4(p.5)] Self-efficacy refers to "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances."[3(p.391)] High levels of self-efficacy are associated with successful and enduring performance. Conversely, low levels of self-efficacy are associated with avoidance of the task or if attempted, a poor performance.[3]

Educational activities need to be directed at increasing self-efficacy for the desired behaviors. Self-efficacy enhancement occurs in four ways.[3] The first and most powerful is actually performing the desired tasks and being successful. The second is by vicarious experience or witnessing someone else being successful. The third way is by receiving verbal encouragement from others. The final route to increased self-efficacy is through interpretation of physiologic cues. Physiologic cues can hamper ability to perform as when one becomes so nervous that performance is fumbled. Conversely, the physiology can remain calm and allow optimal performance.

Attention to the enhancement of students' self-efficacy requires teaching activities that 1) allow the student to perform the task and be successful; 2) provide observational learning by demonstrating others performing procedures correctly; 3) provide verbal encouragement and 4) eliminate debilitating emotional distress.

ATOM attends to all four sources of efficacy information. The laboratory experience gives the student an opportunity to practice skills and be successful. Along with the CD-ROM the laboratory offers observational learning in that the student can witness the repair of injuries on the CD-ROM and also see faculty in the laboratory demonstrate techniques when help is needed.

ATOM instructors act as champions to offer encouragement that the student's mastery is achievable. Finally, ATOM instructors act to calm physiology which may hamper the student's performance. This may be accomplished through stress management, verbal persuasion, and breaking tasks down into smaller more manageable steps to allow success.

As a simulation education experience, ATOM adheres to the principles that guide this type of learning experience.[5] First, the learning objectives of the course must be clear and the critical behaviors that a student must perform to be successful must be identified. The laboratory experience in the ATOM course delineates precisely what must be done to identify each injury, create a treatment plan, and adequately repair the injury. Second, students must need to be prepared for the simulation. ATOM does this by having the student view the CD-ROM prior to attending ATOM. Next, the simulation must be true to life. ATOM uses real-life clinical scenarios of penetrating injury in the porcine laboratory. In the laboratory the human operating room environment is completely replicated so as to mimic the human environment with visual and auditory cues and true to life experiences. Additionally, ATOM identifies student and teacher roles so that all have clear expectations of what is to occur and behaviors that are appropriate. Finally, ATOM provides a debriefing and feedback session for each student where the experience is reviewed and strengths and weaknesses are identified. Debriefing helps students to reflect on their performance during the simulation, so that they may integrate the experience and identify areas for future learning.[5]

EVALUTION OF ATOM PARTICIPANTS

Evaluation of ATOM participants includes assessments in the affective, cognitive and psychomotor domains.[1] For the affective domain, a 25-item self-efficacy instrument asks participants to rate their level of confidence for performing the surgical procedures taught in ATOM. A score of 1 on the self-efficacy instrument indicates very little confidence and a score of 5 indicates quite a lot of confidence. For the cognitive domain a 25-item multiple-choice test assesses knowledge of the content areas taught in the course with each topic being equally represented. The answers to the questions were validated by a panel of expert traumatologists and are supported with references from the literature.[1] ATOM participants complete the knowledge test and the self-efficacy instrument on the World Wide Web prior to taking ATOM and immediately after completing the course. Data from the first 50 participants have clearly shown substantial gains in both knowledge and self-efficacy after taking the ATOM course.[1]

Finally, psychomotor skill in the laboratory is evaluated on a 3-point scale that reflects the degree of assistance needed by the student to complete the task. Students are required to identify the injury, develop a treatment plan, and repair the injury. Critical behaviors to accomplish these essential skills are located in the laboratory for easy reference. One point indicates that the student could not complete the repair. Two points indicate that help was needed. Three points indicate that the student independently repaired the injury.

PRODUCTION OF THE ATOM COURSE

Students arrive at the ATOM course already having completed the registration process via an internet-based on-line demographics questionnaire, having taken the pre-course multiple choice and the pre-course self-efficacy questionnaire and viewing CD-ROM. At the course site ATOM is given in one day with a didactic session in the morning and the laboratory operative session in the afternoon. The didactic portion of the course consists of six thirty-minute lectures. Although only two or three faculty could deliver the lectures, it is preferable for each lecture to be given by a different faculty member, with the course director moderating the introductions and the questions. The operative segment has been described earlier, and the time required to complete the entire afternoon hands-on segment depends largely on the surgical experience of the course participants. The operative portion requires a minimum of 1.5 faculty members per operative table; this facilitates a timely and accurate creation of the standardized injuries that the participants will be expected to diagnose and repair. Once the injuries have been created, only one faculty member is usually needed to assist the participant perform the operative procedures, while discussing the implications of such injuries, and possible alternatives to the repairs being performed. However, the presence of additional faculty

members adds to the educational experience by providing additional input to the course participants.

Each operative station is set up the same manner, and the instrumentation is standardized (Table 3). The initial cost to capitalize the course rests on institutional purchase agreements in place, and is decreased by whatever instrumentation is already available in the animal laboratory/operative suite. Once capitalized, the per-course cost will depend on fixed expenses, such as the cost of the surgical disposables, and controllable costs, such as those related to acquiring faculty. These costs can be markedly decreased by educational and corporate grants, and by coincident laboratory use by other researchers.

TABLE 3 - ATOM BASIC EQUIPMENT LIST.

1	Balfour retractors
1	Finechetto retractor
2	large DeBakey forceps
2	small DeBakey forceps
2	toothed forceps
1	bonnie forceps
2	scalpel handles
2	sponge sticks
1	long vascular needle holder
1	short vascular needle holder
2	regular needle holders
2	right angle clamps
1	fine right angle clamp
6	Kelly clamps
6	mosquito clamps
4	Babcock clamps
4	Alice clamps
4	large towel clips
4	small towel clips
2	Metzenbaum scissors
1	straight mayo scissors
1	Potts scissors
2	DeBakey angled vascular clamps
1	large Satinsky clamp
1	small Satinsky clamp
1	aortic clamp
3	# 10 scalpel blades
1	8 or 10 FR foley catheter (5cc)
1	DeBakey curved vascular clamp
1	small Weitlander retractor
1	Lebske knife & mallet
1	Sternal saw
1	ribbon retractor

TABLE 4 - ATOM COURSE SCHEDULE.

• 0730-0800: Registration, Continental Breakfast & Introduction
• 0800-0930: Lectures The Trauma Laparotomy. Injuries of the Spleen and Diaphragm. Injuries of the Liver.
• 0930-1000: Break
• 1000-1130: Lectures Injuries of the Duodenum and Pancreas. Genitourinary Injuries. Cardiac and Vascular Injuries.
• 1130-1200: Lunch & change to scrubs
• 1200-1600: Operating Room
• 1600-1630: Post-test & evaluations
• 1630-1645: Summary & Adjourn

Time management is a key issue to the successful production of this course. Maintaining a tight timeline for both the didactic and operative session is crucial for the successful completion of the course. A brief post-course debriefing session is helpful. At the end of the course, each student is required to complete an on-line post-course multiple-choice examination and self-efficacy questionnaire, as well as evaluations of the instructors and of the course. A time schedule for ATOM is presented in Table 4.

REPRODUCIBILITY OF THE ATOM COURSE

Each element of the course has been standardized to assure accurate reproducibility.[1] Each lecture is structured so that any instructor can deliver the same content to the students. Similarly, the preparation of the animal including monitoring and resuscitation is also standardized. In the operating room, the injuries are created using a standard methodology so that each student is expected to repair an injury of the same severity. This standardization is achieved by filming

the creation of the injuries and allowing the instructors to accurately reproduce each injury. A senior instructor demonstrates the injury to the junior instructor and has the instructor create the injury prior to being certified as an independent instructor.

The ATOM Course is readily producible and exportable, but it is resource and personnel-intensive. Site requirements include a computer equipped lecture hall and multiple internet access points. A fully equipped operative suite is required. This must be a licensed animal research facility staffed by licensed veterinarians and animal technicians, with established animal care and research protocols that have been approved by both the institutional research review and animal care and use committees. While the faculty requirements are dependent on the number of participants, the overall course size will ultimately depend on the capacity of the sponsoring institution's animal laboratory. Each course requires a course director and coordinator. Faculty members must be board certified (or eligible) trauma surgeons who have successfully completed the ATOM instructor-training course.

Prior to becoming an ATOM site, a senior ATOM instructor evaluates the facility to be sure that all the equipment and personnel are performing according to the standardized course methods. A formal evaluation of the site is presented to the local site director and corrections and any deviations are corrected. The methods of standardizing the educational content, the delivery of the lectures, the education of the instructors, and the operating room instruments and procedures have allowed a uniform standard to be adhered to for the ATOM course no matter where it is offered.

DISCUSSION

The goal of the ATOM course is to provide an educational and operating room environment where a senior surgeon can educate a surgical colleague in the surgical thought processes and technical operating skills necessary to assure a successful outcome in the management of penetrating injuries. The course is best suited for the chief surgical resident or trauma fellow, and the general surgeon who takes trauma call, but who is not a fellowship-trained traumatologist doing trauma surgery on a full time basis.

There have been concerns raised in the literature relative to the difficulty in objectively determining surgical operative competence.[6] ATOM has utilized a rigorous standardization process to address these concerns. It also has provided an atmosphere for a collegial discourse between surgeons at the operating table. It has performed this function in a realistic operating room environment with similar injuries to those that have occurred in the human environment.

There has been a change in the surgical paradigm from using a purely experiential model where the surgeon learns from performing the same operation multiple times in the human environment to a simulation education model where the student is given a series of situations which are derived from the human experience but are carried out in the animal model. This process is one that utilizes an experienced surgeon precepting the trainee through all aspects of the non-operative and operative experience. The senior surgeon is responsible for assuring that the thought processes as well as the psychomotor skills necessary to assure a successful outcome are being implemented.

The ATOM experience allows for 12 to 14 penetrating injuries to be successfully managed in a three to four hour time frame in the operating room. This allows a trainee to be exposed to a substantial volume of operative surgery in a controlled environment at a scheduled time. This methodology allows for scheduled penetrating trauma and has the benefit of allowing the trainee to have an experienced surgeon mentoring them through difficult operative procedures.

BIBLIOGRAPHY

1. *Jacobs LJ, Burns KJ, Kaban JM, Gross RI, Cortes V, Brautigam RT, Perdrizet GA, Besman A, Kirton O. J Trauma. 2003;55:471-479.*

2. *Jacobs LJ, Lorenzo C, Brautigam RT. Conn Med. 2001;65: 265268.*

3. *Bandura A. Social Foundations of Thought and Action: A Social Cognitive Theory. Englewood Cliffs, NJ: Prentice Hall; 1986.*

4. *Gable RK, Wolf MB. Instrument Development in the Affective Domain: Measuring Attitudes and Values in Corporate and School Settings. Boston: Kluwer Academic Publishers; 1993.*

5. *Hertel JP, Millis BJ. Using Simulations to Promote Learning in Higher Education. Sterling, VA: Stylus Publishing, LLC; 2002.*

6. *Darzi A, Datta V, Mackay S. The Challenge of objective assessment of surgical skill. Am J Surg. 2001;181:484-486.*

PELVIC FRACTURES: A MARKER OF INJURY SEVERITY IN TRAUMA

José Gustavo Parreira, MD* Samir Rasslan, MD, FACS**

SUMMARY

Pelvic fractures are truly markers of injury severity. Mortality is considerably high in some situations, complications are expected and long term sequelae possible. The majority of patients sustain concomittant injuries, which definitively have an impact on outcome. Although hemorrhage remains a chief concern, it frequently results from associated injuries in combination with the pelvic fracture. External fixation and angiographic embolization are useful tools in managing the cases of pelvic exsanguination. Especially in patients with persistent shock, a multidisciplinary clinical pathway is mandatory to optimally take care of these patients. The understanding of pelvic anatomy, trauma mechanism and fracture classification enables a better comprehension of possible sites of bleeding and the risk of associated injuries. The knowledge of prognostic factors as well as the main causes of death facilitates the definition of priorities in the management of these patients. A through analysis of the methods to control pelvic hemorrhage allows the correct choice for each situation and institution. Finally, an algorithm for patients sustaining pelvic fractures and persistent shock is proposed, based on all ideas previously discussed.

Keywords

Pelvis, Pelvic fractures, Trauma.

RESUMEN

Las fracturas pélvicas son verdaderos marcadores de severidad de de lesión. En algunas situaciones la mortalidad es considerablemente alta, se deben esperar complicaciones y las secuelas a largo plazo son posibles. La mayoría de los pacientes tienen lesiones concomitantes, las cuales definitivamente tienen un impacto en el resultado. Aunque la hemorragia continúa como la principal preocupación, frecuentemente resulta de las lesiones asociadas en combinación con la fractura pélvica. La fijación externa y la embolización angiográfica son herramientas útiles en el manejo de los casos de exanguinación pélvica. Un manejo clínico multidisciplinario es mandatorio en el cuidado óptimo de estos pacientes, especialmente en aquellos con choque persistente. El conocimiento de la anatomía pélvica, el mecanismo de trauma y la clasificación de la fractura facilita una mejor comprensión del posible sitio de sangrado y el riesgo de lesiones asociadas. El conocimiento de los factores pronósticos asi como las principales causas de muerte, facilita la definición de prioridades en el manejo de estos pacientes. Un análisis directo de los métodos de control de la hemorragia pélvica permite la elección correcta para cada situación y cada institución. Finalmente con base en todas las ideas discutidas, se propone un flujograma para los pacientes con fractura pélvica y choque persistente.

Palabras clave

Pelvis, Fracturas pélvicas, Trauma.

From Emergency Service, Department of Surgery, Santa Casa School of Medicine, Sao Paulo, Brazil.

* Attending surgeon.

** Director. Emergency Service.

INTRODUCTION

Despite all evolution in trauma care, complex pelvic fractures still pose a significant challenge for surgeons. Mortality ranges from 7% to 20% in some series, but certainly it increases markedly if shock and associated injuries complicate the scenario (13,15,18,54,56). Considerable morbidity can still take place, as well as permanent sequelae (9,38,46).

Roughly, 10% of the patients admitted due to blunt trauma sustain a pelvic fracture, yet only 9% of these may be classified as severe (Abbreviated Injury Scale AIS > 3) (17,58). Complex fractures often are mechanically unstable and may be responsible for substantial hemorrhage; however, sometimes the main site of bleeding is not easily recognized (5,19). Hemorrhagic shock occurs in up to 30% of all cases, secondary to exsanguination from pelvic or concomitant injuries (42). As a high number of associated injuries are expected, difficulties in defining priorities might arise (5,54). These lesions must be expeditiously searched and timely treated, since they ultimately interfere with prognosis (42,47).

Various diagnostic exams and treatment options are available for both fracture stabilization and control of hemorrhage (4,23,50). In order to improve prognosis, a systematic approach must be promptly established, which should involve a multidisciplinary team and all necessary resources in a well organized algorithm (5,37,54).

So, the presence of a pelvic fracture must be understood as a marker of injury severity in trauma. Regularly, the challenges in treating these patients are not confined to the pelvis per se, but go beyond its boundaries.

ANATOMY AND MECHANISM OF TRAUMA

Two innominate bones and the sacrum, held in place by some of the strongest ligaments of the body, form the pelvis (36). The posterior sacroiliac ligament, together with the sacrospinous and sacrotuberous ligaments are fundamental in providing mechanical stability (Figure 1). Ligaments between the pubic bones also contribute to maintain this constitution (Figure 1). Many anatomical structures are closely related to these bones, including an extensive venous plexus, branches of hypogastric artery, different nerves and some pelvic viscera.

To break the pelvis, a large impact must occur. The energy necessary to compromise pelvic stability reaches forces of 48 km/h in front impacts and 24 km/h in lateral impacts (35). Three vectors of injury have to be considered in order to understand trauma mechanism: Lateral compression, anterior/posterior compression and vertical shear injuries (15,19,54). These diverse mechanisms bring out specific aspects about volume of hemorrhage, associated injuries and prognosis.

Lateral compression is the most common pattern, accounting for 40 to 60% of pelvic fractures (15,56). A pedestrian struck from the side exemplifies this situation, even though motor vehicle accidents represent the most frequent cause of lateral compression fractures (15,56). Normally, ligaments are not stretched and pelvic stability remains intact. In spite of the magnitude of impact, total volume of the pelvis is habitually preserved. Not surprisingly, these lesions are characterized by an increased number of associated injuries, whereas important pelvic hemorrhage is rarely present (15). Some authors understand the most severe cases of lateral compression fractures as a unique result of crushing forces (15). Contrary to the other subtypes, they are often accompanied by retroperitoneal hemorrhage and few concomitant injuries (15).

Anterior / posterior (AP) forces applied over the pelvis may disrupt ligaments, thereby opening the pelvic ring and increasing its volume. Motorcycle accidents, pedestrian struck and crushed are the most frequent determinants of these fractures (15). These AP forces result in “open book fractures”, which carry an elevated risk for pelvic hemorrhage, retroperitoneal vascular injury, shock, Adult Respiratory Distress Syndrome (ARDS) and death (15). Trauma to the central nervous system is habitually observed in these kind of fractures, compounding a highly lethal association (15).

Vertical shear injuries happen when force is applied on one hemipelvis, as seen in falls with an extended lower extremity. This can damage all ligaments, which might result in vertical instability. Therefore, shock,

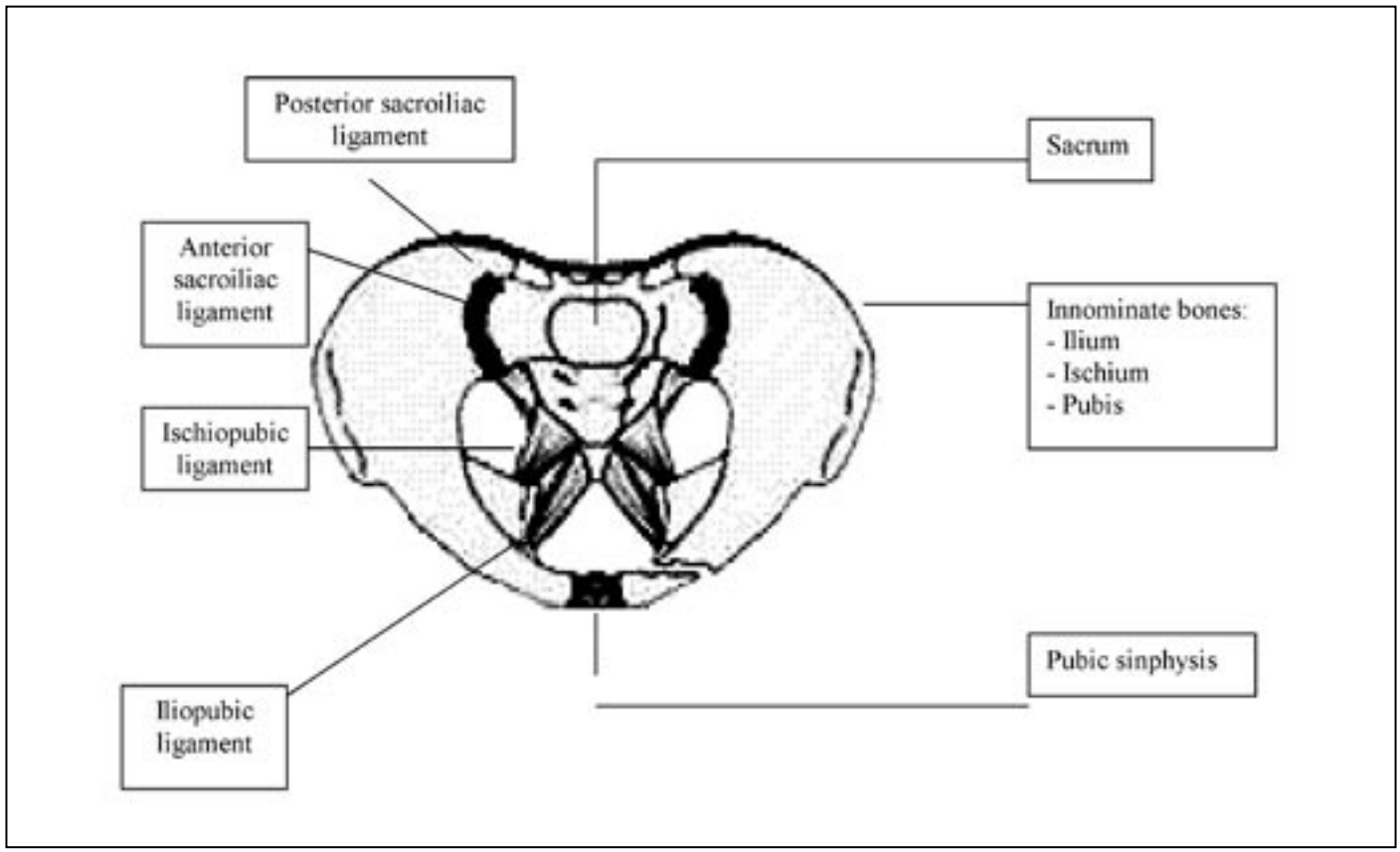


Figure 1. Schematic illustration of pelvic bones and ligaments (from www.trauma.org with permission).

retroperitoneal hematomas and vascular injuries are more common. Abdominal injuries also represent a problem, being more frequently observed in this cohort of patients (15). Some studies describe higher abdominal AIS in victims of vertical shear pelvic fractures (56).

All these vectors might act together, resulting in combined mechanical injuries, when all possibilities must be considered.

SEVERITY STRATIFICATION: CLASSIFICATION

This compelling evidence suggests that differences do exist among patients sustaining pelvic fractures. A classification system is necessary to correctly assess each case, recognizing groups with similar characteristics. A perfect classification would provide enough information to guide treatment, suggest prognosis and delineate possible associated injuries. Nevertheless, the proposal of many schemes anticipates difficulties in classifying theses lesions. Both surgeons and orthopedists look for specific details. Undoubtedly, a classification would be ideally useful if bringing some aid in the practical management.

Kane's modification of Key and Conwell classification grades pelvic fractures in four types, based mainly on integrity of pelvic ring (Table 1) (31). Such scheme addresses only anatomic aspects, not permitting an in depth appraisal of mechanical stability and prognosis (41,42,43). Nevertheless, it is practical and easily applicable, allowing any surgeon to rapidly assess the complexity of the fracture.

Pennel and Sutherland (44) proposed a classification that relies on major vectors of forces. Anatomical findings define three kinds of fractures: antero-posterior compression, lateral compression and vertical shear.

TABLE 1- KANE´S MODIFICATION OF KEY AND CONWELL´S CLASSIFICATION: CORRELATION WITH SHOCK ON ADMISSION, PRESENCE OF ABDOMINAL INJURIES AND MORTALITY (42,43).

Grade	Definition	Shock	Abdominal injuries	Mortality
I	Breaks of individual bones not involving the pelvic ring.	24%	34%	22%
II	Single breaks in the pelvic ring, occurring through both ipsilateral rami, one sacroiliac joint, or subluxation of the symphysis pubis.	17%	43%	15%
III	Double breaks in the pelvic ring. Three subtypes: 1. Malgaigne variants, also called double vertical or dimetric fractures. 2. Bilateral double ramus fractures, referred to as either straddle fractures or "butterfly pattern". 3. Severe multiple or crushing fractures.	45%	54%	21%
IV	Acetabular fractures	-	-	-

However, their initial scheme did not address mechanical stability of the pelvis, limiting its application. This proposal has been modified by Tile, who provided a comprehensive classification based mostly on pelvic stability (59).

Orthopedic surgeons usually prefer Marvin Tile's classification because it permits a correlation with the necessity of bony stabilization and long term sequelae (59). Three groups can be defined: stable fractures (A), horizontal instability solely (B) and horizontal / vertical instability (C). Although excellent in defining orthopedic management, sometimes a wider use is limited because of its poor relation with prognosis and concomitant lesions. Eventually, five different X-rays, as well as a CT scan, are deemed necessary to correctly classify a fracture, which is a major problem in the immediate care of a severely injured patient. A lacking of correlation with the degree of hemorrhage also impairs its application from a general surgeon's point of view (14).

The Young and Burguess modification of Pennel and Sutherland classification has a strong correlation with prognosis, presence of associated injuries and hemorrhage (10,15) (Figure 2). Through a supine anterior –posterior X-ray study together with an inlet and outlet views, the classification can be successfully accomplished. Specific patient profiles accompany each sort of fracture pattern, as described previously (10,15). Moreover, an early detection of the patients at risk for severe hemorrhage is possible, facilitating the arrangements to promptly institute a correct treatment. On the other hand, critics of this scheme are often mentioned, mainly by reason of difficulties in determining exactly the pattern of injury. Occasionally, X-ray studies were proven not easy to interpret.

Cryer et al. also described a scheme based on vector of forces, which tightly relates to outcome indicators (14). The likelihood of severe hemorrhage and concomitant abdominal injuries can be precisely predicted by means of initial X-ray studies, but the real practicability of this proposal has not been broadly tested yet (Table 2).

The true value of pelvic fracture classifications in defining the severity of hemorrhage and prognosis has been questioned recently. Biffl et al. could not establish a correlation between pelvic fracture geometry and ISS, hemoperitoneum, hypotension on admission, use of pelvic angiography and death (5). Starr et al. were unable to demonstrate a clear connection between fracture classes and outcome variables (56). In a previous report, our group analyzed the prognostic factors in patients sustaining pelvic fractures (42). In this study,

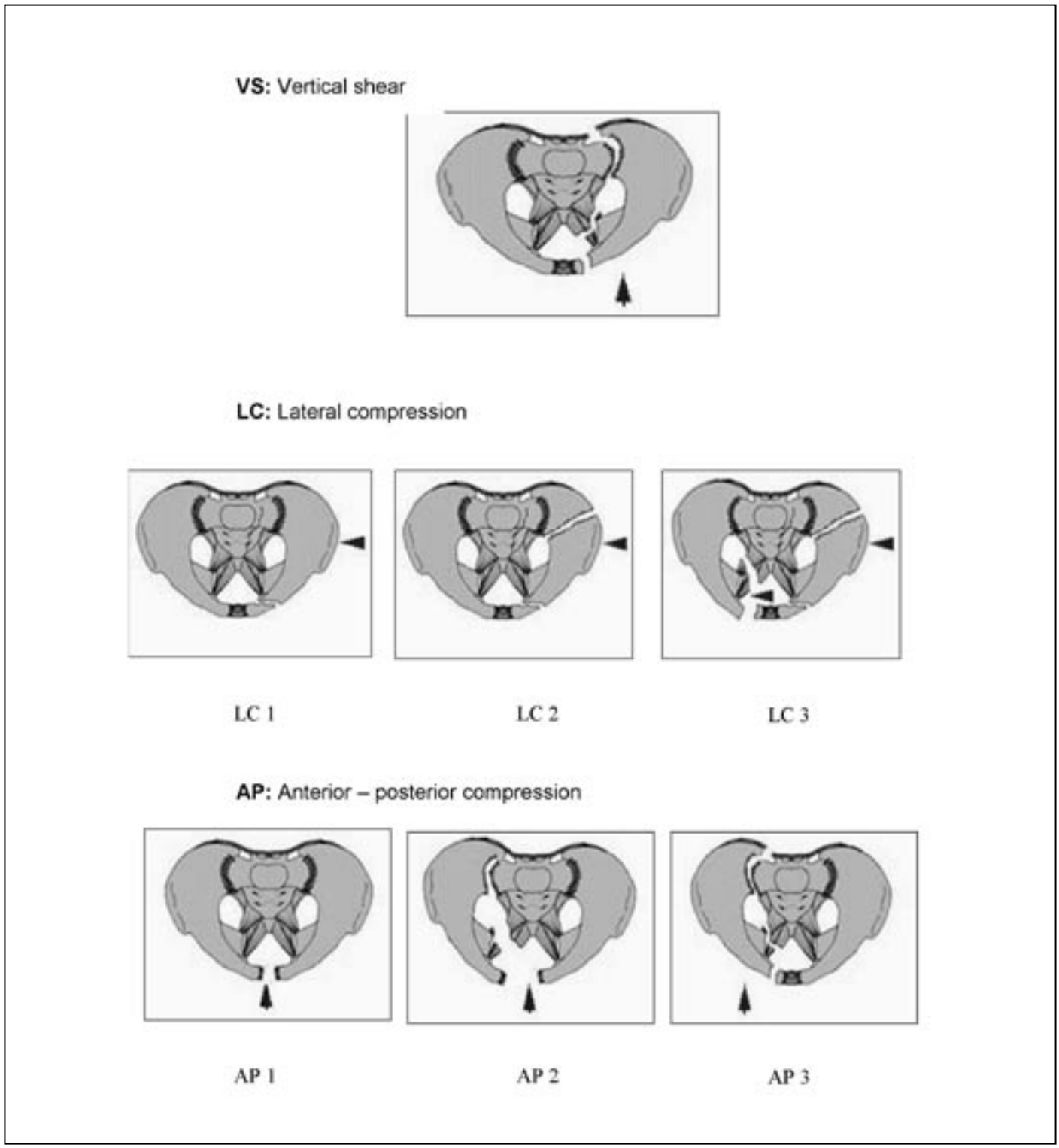


Figure 2. Burguess and Young's modification of Pennel and Sutherland classification for pelvic fractures (from www.trauma.org. with permission)

TABLE 2 - CRYER´S CLASSIFICATION FOR PELVIC FRACTURES: CORRELATION WITH BLOOD REQUIREMENT, ISS, PRESENCE OF ABDOMINAL INJURIES, PELVIC ARTERIAL INJURY AND MORTALITY.

Classification	PRBC (Units)	ISS	Abdominal injuries	Pelvic arterial injury	Mortality
Type I (AP compression)					
Open Book (stable)	9 ± 3	25 ± 8	33%	0	33%
Open book (unstable)	13 ± 3	27 ± 3	50%	19%	31%
Straddle (stable)	2 ± 1	21 ± 2	23%	0	17%
Straddle (unstable)	13 ± 5	24 ± 3	38%	25%	25%
Type II (Lateral compression)					
Anterior + posterior (stable)	2 ± 1	23 ± 3	23%	0	10%
Anterior + posterior (unstable)	10 ± 3	26 ± 4	43%	5%	29%
Miscellaneous (stable)	1 ± 1	17 ± 1	9%	0	8%
Miscellaneous (unstable)	7 ± 3	27 ± 3	29%	7%	7%
Type III (Vertical shear)					
Unstable	10 ± 2	31 ± 3	63%	10%	20%

Modified from Cryer et al. (14).

PRBC: packed red blood cells; ISS: Injury Severity Score.

mortality and morbidity did not vary among different pelvic fractures patterns. However, the occurrence of hemorrhagic shock and the causes of death did differ among groups.

CONSEQUENCES OF PELVIC DISRUPTION

Bleeding from pelvic venous plexus, cancellous bone surfaces and, eventually, named arteries, might result in exsanguination (54). Blood transfusions are required in 30 to 46% (5,17,20). Almost 70% of these patients will receive up to 4 units of packed red blood cells (13,14). In unstable open book or vertical shear fractures, more than 40% will need at least 10 units of packed red blood cells (13,14). Requirements of up to 150 units of packed red blood cells in the first 15 hours after injury has been reported in association with complex pelvic fractures (29). This represents a major concern in these cases. All polytraumatized patients sustaining pelvic fractures should be considered at risk of serious hemorrhage. Therefore, prompt assessment and treatment become essential.

Retroperitoneal hemorrhage originates from the rich pelvic venous plexus and bone fragments in the majority of the cases (5,45). It is quite plausible to accept that low pressure bleeding can be controlled with tamponade. However, the physiologic tamponing capacity is lost whenever an enlargement of pelvic volume takes place, which is commonly secondary to unstable fractures. Grim et al. demonstrated that complex pelvic fractures can reduce in almost fourfold the pelvic tamponing pressure, which might impair hemostasis (27). Furthermore, an enlargement of 4 cm in pelvic diameter can result in an augment in pelvic volume of 1.3 liters (3). Consequently, severe anterior/posterior “open book” fractures, as well as vertically unstable fractures, can really elicit a large amount of bleeding, even without major arterial injuries.

Ruptured branches of hypogastric artery can lead to exsanguination. Although not frequent, the possibility of pelvic arterial hemorrhage should not be underestimated. Patients sustaining unstable pelvic fractures and persistent shock might have active bleeding in 60% of the pelvic angiographies (19). The likelihood of harboring a pelvic arterial hemorrhage rises to 76% if hemodynamic stability is not achieved after mechanical pelvic fixation, transfusions and treatment of concomitant injuries (5).

Patients sustaining posterior pelvic fractures are particularly prone to bleed, since damage to the vascular tree becomes more likely (54). Vertical shear injuries characterize an important example, when laceration of the superior gluteal artery may follow a vertical migration of the hemipelvis (54). AP compression injuries carry a higher risk of exsanguination (15,54). "Open book fractures", the most critical instance, can easily produce hypotension and rapidly determine patients´ death if not treated. Pudendal or obturatory arteries are especially at risk in these fractures (54). Even apparently mild pelvic fractures can be responsible for substantial bleeding. In Moreno et al. series, almost 30% of the patients requiring transfusions of more than 6 units of blood had unilateral anterior fractures (37). As matter of the fact, this may represent an under-diagnosis of the posterior component (37,54).

Injuries to pelvic organs might also complicate the scenario. Bladder, rectum, arterial and nervous branches are at risk. Open fractures should be considered when facing skin, rectum or vagina injuries. If not promptly recognized and treated, they might cause sepsis and death. In addition, an open fracture interferes with the tamponing capacity of the pelvis, favoring a substantial bleeding (50). Nerve injuries accompany posterior fractures more frequently, inflicting long term suffering for these patients (51). Additionally, mechanical pelvic instability not correctly managed may determine pain of difficult treatment, requiring a second operative procedure eventually (51,54). Thus, a number of details must be considered, even at the first moments, in managing these patients.

Not only pelvic viscera might be injured, but other body segments as well. Concomitant injuries also must be highlighted, given that they are frequent, regularly severe and have a tremendous impact on the prognosis. Moreover, these lesions represent hemorrhage sources, obscure physical examination, require specific exams and, sometimes, take the attention away from the pelvis.

IMPORTANCE OF CONCOMITANT INJURIES

Present in as many as 90% of the trauma patients sustaining pelvic fractures, associated injuries play an important role in the prognosis (42,47). As mild stable fractures represent the majority of these cases, it is quite comprehensible that severe concomitant injuries exert a significant impact on outcome.

Concomitant orthopedic injuries, even dislocations or fractures, are the most common associated lesions, being present in up to 50% of the times (17,42,47). Fractures in long bones, as femur and tibia, may elicit considerable hemorrhage. A practical rule to estimate bleeding is to consider a volume of 1500 ml per femur fracture, as well as 700ml per tibia or humerus fracture (3). Additionally, open fractures might also be cause of significant external bleeding and contamination, deserving special attention. Trauma to central nervous system occurs in approximately 40%, and, roughly, is responsible for one third of the deaths in patients sustaining pelvic fractures (13,42). Death is nearly six times more frequent in the presence of head injury with AIS > 2 (42). Cerebral contusions and subdural hematomas were the most common head injuries in our series, certainly decreasing chances of survival (42).

Thoracic trauma happens in one fourth of the patients (42,47). Certainly, rib fractures, hemothoraces and pulmonary contusions account for the majority of examples (42). Mortality increases fivefold in patients presenting thoracic injuries with AIS>2 (42). Aortic tears should be a constant concern in patients sustaining pelvic fractures, as survival depends on the time elapsed until diagnosis and treatment (54). Although not so frequent, these life-threatening lesions must be expeditiously searched. In a recent series with more than 16.000 patients, aortic injuries were present in 1.4% of the ones with pelvic fractures, while the incidence was 0.4% for the others, which represents a statistically significant difference (17). Others have stated that the risk of aortic rupture is eight times greater in patients with pelvic ring disruptions (40).

Abdominal injuries take place in 30 to 40% of the patients, with an AIS>2 in 28% (6,42,43). Urologic system is particularly involved, as bladder is injured in up to 10%, urethra in 6% and kidney in 6% (32,42,48). Approximately 15% of the patients sustain liver or spleen injuries, while major vascular injuries are rare (42). More than 50% of the diagnosed abdominal injuries can be scored with AIS of three or more.

Interestingly, the more severe the pelvic fracture, the more frequent are abdominal injuries (17,42). Demetriades et al. reported abdominal injuries in 15% of the patients with mild pelvic fractures (AIS≤3), whereas this number increased to 30% in face of a severe fracture (AIS>3) (17). These authors also noted that the chance of having a liver injury is higher in patients with complex pelvic ring disruptions.

Consequently, the likelihood of sustaining an abdominal injury is directly related to the severity of pelvic fracture. Additional predictors of abdominal injuries include shock on admission, unstable pelvic fractures, lower RTS and higher ISS. It is worth remembering that mortality rises appreciably in face of an abdominal injury (42,43).

CAUSES OF DEATH AND PROGNOSTIC FACTORS

At the beginning of the 20th century, retroperitoneal hemorrhage was responsible for the majority of the deaths (13). The refinement of methods to control pelvic bleeding as early external fixation and angiographic embolization introduced a new era in the management of these patients (13,23,24,50).

Reviewing series published from 1990 to 2002, the mortality ranged between 5% and 17% (5,10,17,19,28,42,56). These rates might give the wrong idea that patients with pelvic fractures would not deserve special attention. On the contrary, mortality rates might augment to 25 to 35% in face of unstable pelvic fractures, especially if accompanied by a severe concomitant injury (15). Impressively, almost 60% of the patients succumb in the presence of shock, complex fractures and abdominal lesions (19,42).

Three main causes of death usually come about in polytraumatized patients with pelvic fractures: hemorrhage, trauma to the nervous system and multiple organ failure (13). Roughly, each one of these causes account for nearly one third of the total number of deaths.

When analyzing the source of bleeding in patients with pelvic fractures who died, normally we find various sites. In fact, isolated retroperitoneal hemorrhage is rare. In our series, a third of the deaths due to hemorrhage were secondary to pelvic exsanguination (42). Most common causes of bleeding were abdominal organs, principally the liver and spleen. In 236 patients with pelvic fractures, Poole et al. described only one death deemed to be secondary to pelvic exsanguination (47). In Demetriades et al. cohort of 1545 patients with pelvic fractures, only 12 deaths could be directly related to the pelvic fracture (0,8%) (17).

The potential danger of exanguination in the presence of a pelvic fracture should not be underestimated. This low rate of death due to pelvic hemorrhage is true as long as a definite policy to control pelvic bleeding is applied. Furthermore, association among various sources of hemorrhage is common, including pelvic fractures (41,42). Hemorrhagic shock, maintained by pelvic fractures oozing, might worsen head injuries outcome, elicit a systemic inflammatory response due to a low flow period, as well as contribute to late immunosupression (54). These problems work together to finally determine death. Mucha et al. affirmed that pelvic fractures are directly responsible for 12% of the deaths, contribute somehow in more 53% and have no relation with 35% (39).

Trauma to the central nervous system accounts for approximately 30% of the demises (13). Lateral impact victims are particularly at risk for this cause of death (15). Systemic inflammatory response, sepsis, and multiple organ failure (MOF) determine the final outcome in almost 30% of patients (13). Certainly, some of these cases had hemorrhagic shock as the primary insult. As a matter of fact, hemorrhage, ARDS and MOF have been described as important causes of death in patients with AP fractures, who also have a significant incidence of head injuries (15).

The main predictors of death are pedestrian struck as mechanism of trauma, shock upon admission, severe associated lesions, RTS and ISS (42,52). Curiously, severity and stability of fracture did not influence the final outcome in some papers (5,42,47). Pedestrian struck has been associated with more severe pelvic fractures, mostly in AP pattern, as well as higher ISS (15,18,42,52). Starr et al. recognized the presence of shock on admission and a RTS < 11 as consistent

predictors of death. A considerable amount of data really validates the role of associated injuries on the outcome (17,42,47). The presence of a concomitant injury with AIS > 2 increases mortality independently of the pelvic fracture pattern. Moreover, through a logistic regression analysis, Demetriades et al. demonstrated that ISS higher than 25 definitely correlates with lethality (17).

Nevertheless, the real influence of associated injuries on the outcome of patients sustaining pelvic fractures admitted in shock is not so clear. Our group evaluated this issue previously, when just head injuries with AIS > 3 really had a significant impact on prognosis (41). The results appear the same when only unstable fractures are considered. Therefore, it seems that physiologic derangement is the most important prognostic factor in these unstable patients carrying complex fractures.

Mortality also depends on age groups. Although geriatric patients present fewer associated lesions and less severe pelvic fractures, their mortality rate is higher (2). Exacerbation of underlying cardiovascular diseases really compromises the outcome (2). On the other hand, the pediatric population has a better prognosis. Pelvic ring disruptions seem to be less frequent and carry a lower lethality (30).

Open pelvic fractures were believed to determine a worse prognosis. However, nowadays this tendency might not be totally true. Good outcomes have been described in patients sustaining this lesion (16,22). A strict policy of treatment is required, and, in selected opportunities, fecal diversion is indispensable (21).

INITIAL MANAGEMENT

Primary and secondary assessments are carried out as delineated for the Advanced Trauma Life Support course of American College of Surgeons (3). It is very important to follow the sequence of priorities, concerning the maintenance of a pervious airway, efficient ventilation and adequate volume status, especially for victims of trauma in multiple body segments.

Special attention should be given for the evaluation and treatment of hemorrhagic shock. Long bone fractures, thoracic or abdominal injuries, along with the pelvic fracture might result in exsanguination. Thus, an active searching for the source hemorrhage should be promptly initiated. If a pelvic fracture is thought to be the main hemorrhage site, some measure must be taken to control retroperitoneal bleeding. In contrast, if another hemorrhaging lesion is considered life-threatening, it should become the main priority. Therefore, a multidisciplinary approach assures the best results in managing these patients.

Together with these haemostatic measures, an aggressive resuscitation with warmed crystalloids is necessary. Another important point is to keep a low threshold for transfusion of blood products. Based on the mechanism of trauma, associated lesions and pattern of the pelvic fracture, the surgeon can predict the risk of exsanguination (34). Postponing the infusion of packed red blood cells actually contributes to a longer period of deficient oxygen delivery. Moreover, some groups advocate the presumptive transfusion of clotting factors, as coagulopathy is deemed to be present even before the alterations in coagulation tests (5).

CONTROLLING PELVIC HEMORRHAGE

Basically, there are four methods to control retroperitoneal hemorrhage: External compressive devices, external fixation, selective angiography with embolization, and operative hemostasis (54).

Among the most common compressive devices, military antishock garments (MAST), pelvic clamps, as well as bed sheet wrapping have been discussed. There are limited indications for military antishock garments in the present time. One of the few applications may be unstable pelvic fractures (54). If correctly employed, this device can stabilize fractures, acting as a pelvic splint (54). However, skin lesions and, more importantly, abdominal compartment syndrome can take place, impairing even more the hemodynamic status in these severe patients (54). Pelvic C - clamps are thought to have various advantages, including the capacity of stabilizing posterior elements, versatility of application in the emergency room as well as the relative mobility of the arch, which permits better abdominal exposition during an eventual laparotomy (54). Nevertheless, a well trained orthopedic surgeon must be readily available to

apply this apparatus. Costs also might limit a larger use of pelvic clamps in the emergency setting.

Wrapping the pelvis tightly with a bed sheet, together with the bidding of knees and ankles, has been accepted as an effective initial procedure to control pelvic hemorrhage (55). It is easily performed, not harboring any hazardous risks for the patient. In fact, some institutions have been using it as a temporary measure until the external pelvic fixation (54,55).

There have been countless debates about the best method to control retroperitoneal bleeding from pelvic ring disruptions. Some advocate that early external fixation should be the first step in unstable fractures (8,33,45,50). Others propose angiographic embolization as the method of choice in this setting (1,4,12,23,24,26,28). Actually, they do not represent competing methods, but complementary ones. Many factors influence this selection, which should take in consideration the fracture stability, necessity of a concomitant laparotomy as well as the availability of specialists and resources.

Riemer et al. reduced mortality in patients sustaining pelvic fractures by adding early anterior pelvic external fixation to their treatment protocol (50). While the number of patients receiving external fixation increased from 0% to 31% during the study period, the mortality for all group decreases from 26% to 6%. Regarding solely cases admitted in shock, mortality decreased from 44% to 21%. The authors state that the reasons for bleeding control by this method are not totally clear (50). They judge that the tamponing effect, created by reducing the pelvic volume, would not explain completely the results, since effective control of hemorrhage was observed in cases with no significant reduction of the pelvic volume and open fractures. Another advantage of early external fixation is a better relief of the pain, allowing mobilization to an upright position.

Other authors recommend early external fixation as the first step in managing patients with retroperitoneal hemorrhage due to pelvic ring disruptions (45,54). This statement is based on the fact that the majority of pelvic hemorrhage originates from pelvic veins or cancellous bones, representing a low pressure bleeding that would be amenable for the tamponade hemostasis. Grim et al. verified in a study in cadavers that external fixation increased the pressure in the retroperitoneum, and, therefore, probably play a role in hemostasis (27). Revising data from our institution, we noticed that nearly 30% of the patients with pelvic fractures need fixation of the pelvis, and only 10% of the deaths were due to pelvic hemorrhage (42).

Pelvic angiography and embolization has been recommended with diagnostic and therapeutic purposes (60). Its real application varies with institutional preferences, depending on the proposed algorithm for managing patients with pelvic fractures. Average need is around 5% (17,61). In series analyzing patients with complex pelvic fractures, 15% required the procedure. However, considering only patients receiving blood transfusions, angiography was carried out in almost 30% (5). During the procedure, active arterial bleeding is verified in 75% and embolization is achieved in approximately 95% (1,5).

One of the most important points of discussion lies on the time elapsed to initiate angiography. Even in centers employing protocols where angiography precedes pelvic fixation, it takes some time to prepare the operative suit and gather the team (1,19). At least one hour is necessary to begin the procedure in some of the fastest centers (1,19). This period can be larger in ordinary hospitals (54). Leading trauma centers also report an average time to complete the procedure around 90 minutes (1,19). This contrast with the time estimated to place a pelvic C clamp, which is around 5 minutes (5).

The mortality of patients that undergo angiographic embolization reaches 17% (61). Prognosis relates to the rate of blood transfusions before the procedure (61). Agolini et al. stated that mortality would be statistically lower if embolization was accomplished in less than 3 hours of arrival (1). Thus, there is a trend toward an early, yet selective, indication for angiography in patients sustaining pelvic fractures.

To bear in mind all this information is of essence in order to select the best manage options in each institution. Certainly, some discordance about priorities can arise, but a considerable amount of data is available to assist in this decision.

DEFINING PRIORITIES

The high incidence of abdominal injuries brings up some problems in determining priorities, as long as these lesions may cause considerable hemorrhage and even death. Patients in shock might sustain bleeding to the peritoneal cavity, to the retroperitoneum or both. Whereas patients with an abdominal source of hemorrhage need a laparotomy, retroperitoneal bleeding from pelvic fractures disruptions requires external fixation and/or angiographic embolization. As stated before, there is a strong association between complex pelvic fractures and abdominal injuries, and they often happen concomitantly.

Therefore, some discordance about what to treat first, an eventual abdominal injury or an ongoing pelvic hemorrhage, may occur. One potential mistake is to perform a laparotomy, to find only a huge retroperitoneal hematoma and realize that the patient should have undergone some form of pelvic hemorrhage control. In contrast, to leave an ongoing intra-abdominal hemorrhage without treatment while waiting for pelvic angiography or fracture fixation might be a potentially lethal error.

Non-therapeutic laparotomies in these extremely unstable patients carry a dire prognosis (49). In our series, mortality in patients with pelvic fractures that underwent non-therapeutic laparotomies attained 76% (42). This can be explained in part by the delay in treatment of the real source of hemorrhage. Moreover, some groups believe that the abdominal wall provides stability to an unstable pelvic ring, since a laparotomy might increase pelvic volume in 15% (25). Hence, opening the abdomen may elicit more bleeding from pelvic vessels. Errors in defining priorities are not allowed in these severe cases.

So, a correct triage is imperative. Determining the presence of abdominal bleeding is a key point for the decision-making process. If the patient remains hemodynamically unstable despite volume replacement, Focused Assessment Sonography for Trauma (FAST) and/or Diagnostic Peritoneal Lavage characterize the best options (DPL) (7,53). If hemodynamic stability can be accomplished, computed tomography allows a sensible and specific assessment of abdominal organs, pelvic fracture and bleeding from retroperitoneum (11,57).

When DPL results are grossly positive, life-threatening intra-abdominal injuries are present in 30% to 84% (14,37). On the other hand, microscopically positive DPLs carry a chance of 50% of negative abdominal explorations (Flint). A positive FAST exam denotes an elevated chance of positive laparotomy in patients with hemodynamic instability (5). Biffl et al., studying patients sustaining pelvic fractures that required blood transfusions, found positive FAST exams in 23% (5).

Eastridge et al. recently published their experience with hemodynamically unstable patients sustaining pelvic fractures (19). Patients with persistent hypotension and a stable pelvic fracture presented active intra-peritoneal hemorrhage in 65% along with active pelvic arterial bleeding in 10%. In contrast, the association of persistent shock and unstable pelvic fractures faces active intra-abdominal hemorrhage in 30% and active pelvic arterial bleeding in 60%. Concomitance of pelvic and abdominal exsanguination happened in almost 30%, with a mortality of 56%.

It is imperative to promptly treat any site of hemorrhage, no matter whether it is in the abdomen, pelvis or both. Scalea hypothetically suggested that these extreme cases should be managed in an operating room with biplanar angiographic capability, in which all sites of bleeding could be treated simultaneously (19-Comments). Furthermore, this scaring death rate in patients with multiple sites of exsanguination characterizes a precise indication for damage control. The ideal of interrupting the cycle of metabolic acidosis, hypothermia and coagulopathy should be always kept in mind. So, abbreviated operations must be considered for these critical situations.

SUGGESTED ALGORYTHM

A multidisciplinary approach becomes essential, even in the first moments of admission. This should encourage the surgeon to work together with the orthopedist, radiologist, vascular surgeon, nursing and blood bank personal. Various multidisciplinary clinical pathways

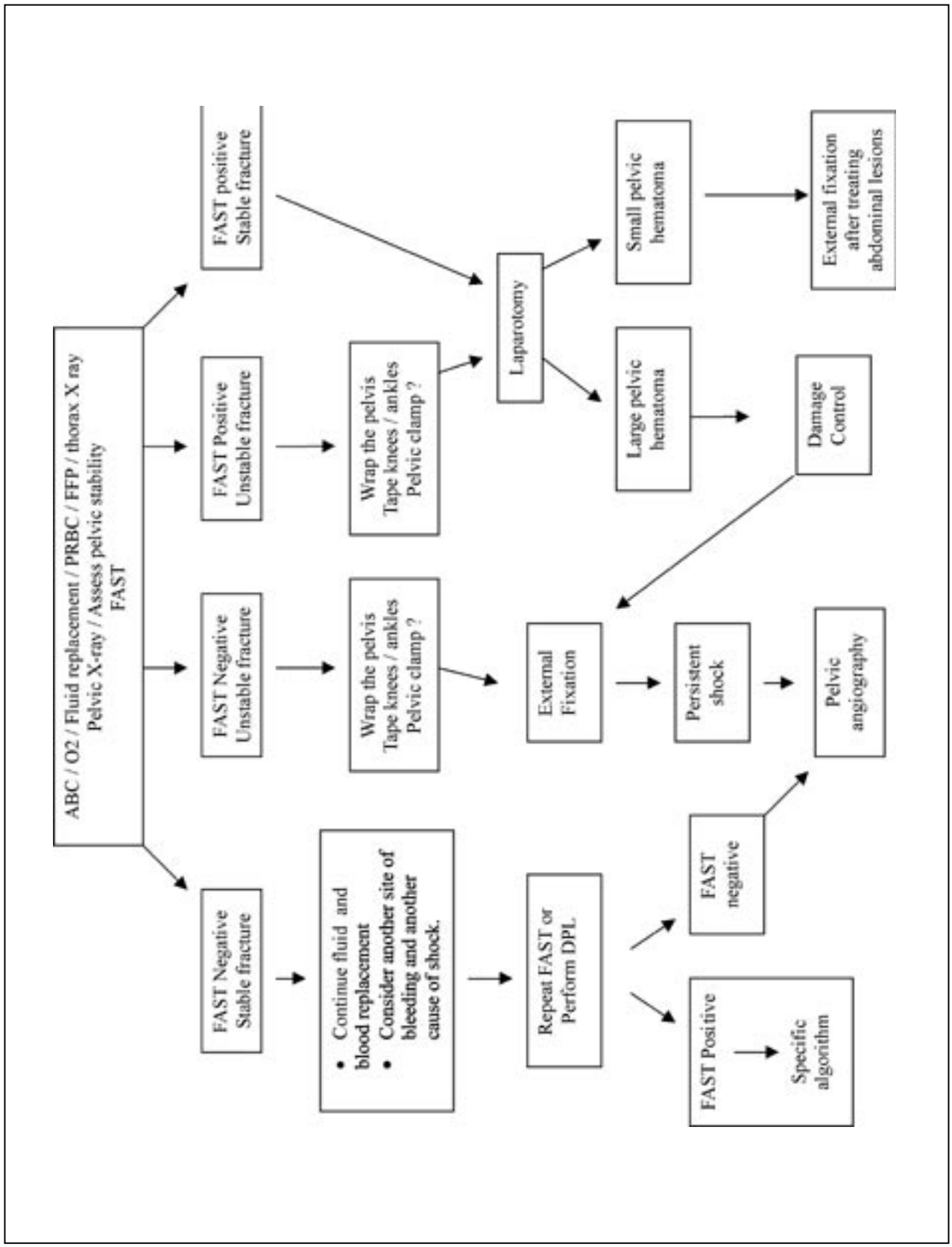


Figure 3. Algorithm suggested for patients sustaining pelvic fractures with persistent shock.

have been proposed, based principally on the available resources (5,54).

Actually, hemodynamically unstable patients with pelvic fractures characterize a critical situation that requires a rapid and effective sequence of actions to accomplish the best results. In this scenario, some measures are deemed necessary. While the team performs a complete assessment and resuscitation, orthopedic surgeons are notified to be present in the emergency room, with the aim of helping in the decision process. Thorax and pelvic X-ray studies as well as FAST guide next steps in the algorithm (Figure 3).

Patients sustaining persistent shock despite volume resuscitation together with a negative FAST and a stable fracture need reassessment of other sites of bleeding, another cause of shock and a concern of insufficient volume replacement. To assure the absence of hemorrhage in abdomen, repeating FAST or performing a DPL must be considered. If no other source of bleeding is found and shock persists, pelvic angiography might be necessary to rule out active bleeding.

In face of an unstable pelvic fracture and negative FAST, fixation of the pelvis must be rapidly achieved in the emergency room. Best options would be wrapping the pelvis with a bed sheet or placing a pelvic C clamp. The patient is rushed to the operative room to undergo external pelvic fixation. If shock remains, pelvic angiography is the next step to control pelvic hemorrhage.

In the presence of fluid in abdomen or a grossly positive DPL, patient should undergo a laparotomy. However, fixation of unstable fractures in the emergency department must be accomplished by the same methods described. During the laparotomy, surgeon must appraise the real source of hemorrhage. If a large pelvic hematoma is present, probably is due to an active bleeding. Retroperitoneal cavity should not be explored. Rather, the surgeon should pack the pelvis, expeditiously control any source of abdominal hemorrhage and proceed to complete an abbreviated laparotomy. At this moment, definitive treatment of abdominal injuries should be avoided, as hemorrhage is still the major problem. The external pelvic fixation must be placed rapidly, and, if hemodynamic status does not improve, angiography must be carried out.

On the other hand, if the main source of hemorrhage is deemed to be abdominal, all abdominal injuries should be definitively treated, and the external fixation placed after it.

FINAL COMMENTS

The management of polytrauma patients sustaining pelvic fractures depends on a complete comprehension of the trauma mechanism, the consequences of pelvic disruption and all methods to diagnose and treat possible injuries. To recognize the priorities promptly is essential. A low threshold for the treatment of hemorrhagic shock, associated with an expeditious searching of the hemorrhage source are indispensable to get better outcomes. All care must be supported for a multidisciplinary team, which should be involved early in the treatment.

BIBLIOGRAPHY

1. *Agolini SF, Shah K, Jaffe J et al. Arterial embolization is a rapid and effective technique for controlling pelvic fracture hemorrhage. J Trauma 1997, 43: 395 – 399.*

2. *Alost T, Waldrop RD. Profile of geriatric pelvic fractures presenting in the emergency department. Am J Emerg Med 1997, 15: 576 – 578.*

3. *American College of Surgeons Commitee on Trauma: Advenced Trauma Life Support For Doctors – Instructor Course Manual. Chicago, American College of Surgeons, 1997, 990p.*

4. *Bassan D, Cephas GA, Fergusson KA et al. A protocol for the initial management of unstable pelvic fractures. Am Surg 1998, 64: 862 – 867.*

5. *Biffl WL, Smith WR, Moore EE, et al. Evolution of a multidisciplinary clinical pathway for the management of unstable patients with pelvic fractures. Ann Surg 2001, 233: 843-849.*

6. *Bond S, Gotschall C, Eichelberger M. Predictors of abdominal injury in children whit pelvic fracture. J Trauma 1991, 31: 1169 - 1173.*

7. *Boulanger B, Rozycky G, Rodriguez A. Avaliação ultrassonográfica da lesão traumática. Clin Cir Am Norte 1999, 79: 1227-1246.*

8. *Broos P, Vanderschot P, Craninx L, et al. The operative treatment of unstable pelvic ring fractures. Int Surg 1992, 77: 303– 308.*

9. *Buerger PM, Peoples JB, Lemmon GW et al. Risk of pulmonary emboli in patients with pelvic fractures. Am Surg 1993, 59: 505 – 508.*

10. *Burguess AR, Eastridge BJ, Young JWR et al. Pelvic ring disruptions: effective classification system and treatment protocols. J Trauma 1990, 30: 848-856.*

11. *Cerva DS, Mirvis SE, Shanmuganathan K et al. Detection of bleeding in patients with major pelvic fractures: value of contrast enhanced CT. AJR 1996, 166: 131 – 135.*

12. *Cook RE, Keating JF, Gillespie I. The role of angiography in the management of hemorrhage from major fractures of the pelvis. J Bone Joint Surg 2002, 84: 178- 182.*

13. *Cryer HG, Johnson EE : Pelvic Fratures. In Feliciano D, Moore EE, Mattox K.: Trauma - 3rd ediction. Stamford, Connecticut. Appleton and Lange, 1996, pp 635 - 661.*

14. *Cryer HM, Miller FB & Evers BM - Pelvic fracture stabilization: correlation with hemorrhage. J Trauma 1988; 28: 973.*

15. *Dalal SA, Burgess AR, Siegel J et al. Pelvic fracture in multiple trauma: classification by mechanism is key to pattern of organ injury, resuscitative requirements and outcome. J Trauma 1989, 29: 981 – 1000.*

16. *Davidson BS, Simmons GT, Williamson PR et al. pelvic fractures associated with open perineal wounds: a survivable injury. J Trauma 1993, 35: 36 – 39.*

17. *Demetriades D, Karaiskakis M, Toutouzas K et al. Pelvic fractures: epidemiology and predictors of associated abdominal injuries and outcomes. J Am Coll Surg 2002, 195: 1 - 10.*

18. *Eastridge B, Burgess A: Pedestrian pelvic fractures: 5-year experience of a major urban trauma center. J Trauma, 1997, 42: 695 - 700.*

19. *Eastridge BJ, Starr A, Minei JP at al. The importance of fracture pattern in guiding therapeutic decision making in patients with hemorrhagic shock and pelvic ring disruptions. J Trauma 2002, 53:446 - 451.*

20. *Evers BM, Cryer HM, Miller FB. Pelvic fracture hemorrhage. Arch Surg, 124: 422 – 425.*

21. *Faringer PD, Mullins R, Feliciano PD et al. Selective fecal diversion in complex open pelvic fractures from blunt trauma. Arch Surg 1994, 129: 958 – 964.*

22. *Ferrera PC, Hill DA. Good outcomes of open pelvic fractures. Injury 1999, 30: 187 – 190.*

23. *Flint L, Brown A, Richardson JD et al. Definitive control of bleeding from severe pelvic fractures. Ann Surg 1979, 189: 709 – 714.*

24. *Flint L, Babikian G, Anders M et al. Definitive control of mortality from severe pelvic fracture. Ann Surg 1990, 211: 702 - 707.*

25. *Ghanayem AJ, Wilber JH, Lieberman JM et al. The effect of laparotomy and external fixator estabilization on pelvic volume in an unstable pelvic injury. J Trauma 1995, 38: 396- 400.*

26. *Gilliland MG, Ward RE, Flynn TC et al. Peritoneal lavage and angiography n the management of patients with pelvic fractures. Am J Surg 1982, 144: 744 – 746.*

27. *Grimm MR, Vrahas MS, Thomas KA. Pressure-volume characteristics of the intact and disrupted pelvic retroperitoneum. J Trauma 1998, 44: 454-459.*

28. *Gruen GS, Leit ME, Gruen RJ. The acute management of hemodynamically unstable multiple trauma patients with pelvic ring fractures. J Trauma 1994, 36: 706 - 713.*

29. *Hakala P, Lindahl J, Alberty A et al. Massive transfusion exceeding 150 units of packed red cells during the first 15 hours of injury. J Trauma 1998, 44:410 – 412.*

30. *Ismail N, Bellemare JF, Mollit D et al. Death from pelvic fracture: children are different. J Ped Surg 1996, 31: 82– 85.*

31. *Kane WJ - Fractures of the Pelvis. In Rochwood CA, Green DP: Fractures. Philadelphia, JB Lippincott, 1984, pp1093.*

32. *Koraitin M - Pelvic fracture urethral injuries: the unresolved controversy. J. Urol, 1999, 161: 1433 - 1441.*

33. *Latenser BA, Gentinello LM, Tarver AA, et al. Improved Outcome with Early Fixation of Skeletally Unstable Pelvic Fractures. J Trauma 1991, 31: 28 - 31.*

34. *Looser KG, Crombie HD - Pelvic Fractures. An anatomic guide to severity of injury. Review of 100 cases. Am J Surg 1976; 132 : 638 - 642.*

35. McCoy GF, Johnstone RA, Kenright J - Biomechanical aspects of pelvic and hip injures in road traffic accidents. J Orthop Trauma 1989; 3: 118 - 123.

36. Moore KL. The Pelvis and perineum. In: Clinically oriented anatomy. 3rd ed. Baltimore, Willians & Wilkins. 1992. pp 243-322.

37. Moreno C, Moore EE, Rosenberger A, et al. Hemorrhage associated with major pelvic fracture: a multispeciality challenge. J Trauma, 1986, 26: 987 – 993.

38. Mucha P Jr - Recognizing and avoiding complications with pelvic fractures. Infect Surg 1985; 4: 53 - 62.

39. Mucha P Jr- Pelvic Fractures. In Mattox K, Moore EE, Feliciano D: Trauma – 2nd ed. Stamford, Connecticut. Appleton and Lange, 199 , pp553 - 569.

40. Oschsner MG, Hofman AP, DiPasquale D et al. Associated aortic rupture – pelvic fracture: an alert for orthopedic and trauma surgeons. J Trauma1992, 33: 429 – 434.

41. Parreira JG, Coimbra R, Silva LE et al. - A critical analysis of prognostic factors in patients sustaining pelvic fractures admitted in shock. Panam J Trauma 1998, 7: 27-33.

42. Parreira JG, Coimbra R, Rasslam S et al. The role of associated injuries on outcome of blunt trauma patients sustaining pelvic fractures. Injury 2000, 31: 677-682.

43. Parreira JG, Haddad L, Rasslan S. [Abdominal injuries in patients sustaining pelvic fractures]. Rev Col Bras Cir 2002, 29: 153 – 160.

44. Pennal GF, Tile M, Waddel JP, et al. Pelvic disruption assessment and classification. Clin Orthop Rel Res 1979, 151: 12-21.

45. Polka A & Libby EP. Indications and techniques for external fixation of the pelvis. Clin Orth Rel Res 1996, 329: 54 – 59.

46. Poole G, Ward EF, Griswold JÁ et al. Complications of pelvic fractures from blunt trauma. Am Surg 1992, 58: 225- 231.

47. Poole G, Ward EF, Muakassa FF et al. - Pelvic fracture from major blunt trauma. Outcome is determined by associated injuries. Ann Surg, 1991; 213: 532 – 538.

48. Rehn C, Mure A, Malley K et al - Blunt traumatic bladder rupture: the role of retrograde cystogram. Ann Em Med, 1991, 20: 845 - 847.

49. Renz BM & Feliciano D - Unnecessary laparotomies for trauma: a prospective study of morbidity. J Trauma 1995; 38: 350.

50. Riemer BL, Spencer LB, Diamond DL et al. Acute mortality associated injuries to the pelvic ring: The role of early patient mobilization and external fixation. J Trauma 1993, 35: 671 - 677.

51. Rommens PM. Pelvic ring injuries: a challenge for the trauma surgeon. Acta Chir Belg 1996, 96: 78 - 84.

52. Rothenberger D, Fischer R, Strate R et al - The mortality associated with pelvic fractures. Surgery, 1978, 84: 356- 361.

53. Rozycki GS & Shackford S – Ultrasound, what every trauma surgeon should know. J Trauma, 1996, 40: 1-4.

54. Scalea T, Burgess A: Pelvic Fratures. In Mattox K, Feliciano D, Moore EE: Trauma - 4th ediction. United States of America. McGraw-Hill, 2000, pp 807-836.

55. Simpson T, Krieg JC, Heuer F et al. Stabilization of pelvic ring disruptions with a circumferential sheet. J Trauma 2002, 52: 158 - 161.

56. Starr AJ, Griffin DR, Reinert CM, et al. Pelvic ring disruptions: predictors of associated injuries, transfusions requirements, pelvic angiography, complications and mortality. J Orthop Trauma 2002, 16: 553 – 561.

57. Stephen DJG, Kreder HJ, Day AC et al. Early detection of arterial bleeding in acute pelvic trauma. J Trauma 1999, 47: 638 – 642.

58. The Abbreviated Injury Scale. 1990 Revision. Association for Advancement of Automotive Medicine. 1990, Des Plaines, IL 60018, USA.

59. Tile M. Fractures of the pelvis and acetabulum. Baltimore: Willians and Wilkins, 1984.

60. Velmahos GC, Toutouzas KG, Vassiliu P et al. A prospective study on the safety and efficacy of angiographic embolization for pelvic and visceral injuries. J Trauma 2002, 52: 303– 308.

61. Wong YC, Wang LJ, Ng CJ et al. – Mortality after successful transcatheter arterial embolization in patients with unstable pelvic fractures: rate of blood transfusion as a predictive factor. J Trauma, 2000, 49: 71-74.

PITFALLS AND PROMISES OF LAPAROSCOPY IN THE EVALUATION OF THE TRAUMA PATIENT

Ronald H. Clements, MD, Kimball I. Maull MD

SUMMARY

Laparoscopy is a safe and effective modality to screen, diagnose and treat traumatic injuries of the abdomen when used in properly selected patients by a surgeon experienced and trained in minimally invasive techniques. There are limitations to its usefulness that must be realized and not exceeded. As equipment, instrumentation and experience improve, it is likely that these limitations will need to be continually readjusted. Its most useful role at this time is in screening the abdomen for the indication for celiotomy. However, the advantages already realized in the non-trauma patient are impressive enough that this technique merits further investigation and use in those at risk for abdominal injury.

Keywords

Laparoscopy, Trauma, Abdominal trauma.

RESUMEN

La laparoscopia es una modalidad segura y eficaz para investigar, diagnosticar, y tratar las heridas traumáticas de abdomen cuando se utiliza en los pacientes adecuadamente seleccionados por un cirujano experto y entrenado en técnicas laparoscópicas. Hay limitaciones en su utilidad que deben ser observadas y no excedidas. Conforme mejoran los aparatos, la instrumentación, y la experiencia, es probable que estas limitaciones continuamente necesiten un reajuste. Su papel más útil en este momento consiste en investigar el abdomen para la indicación de laparotomía. Sin embargo, las ventajas observadas en los pacientes no traumatizados, sugieren que esta técnica merece una investigación adicional y su empleo en los pacientes traumatizados con riesgo de lesión intrabdominal.

Palabras clave

Laparoscopia, Trauma, Trauma abdominal.

INTRODUCTION

Optimal care of the traumatized patient continues to evolve. While physical examination remains an essential component of injury assessment, additional diagnostic tests are often necessary to avoid missed injuries which can lead to increased morbidity and mortality if left untreated. This dilemma has led to the development and implementation of an impressive array of diagnostic and therapeutic modalities, none of which has proven to be totally accurate or reliable.

All currently available techniques to evaluate abdominal trauma have limitations. As familiarity and facility with laparoscopy have become more widespread, many clinicians have turned to laparoscopy to diagnose and treat this common problem. It must be realized that even though there are several attractive aspects to laparoscopy in trauma, it has not proven to be the panacea. This report examines the pitfalls and promises of this technique.

The Trauma Center at Carraway, Carraway Methodist Medical Center. Department of Surgery Norwood Clinic Birmingham, Alabama, USA.

PITFALLS

Although the ability to directly visualize peritoneal structures without a large incision would appear to be a preferred method of diagnosing abdominal injuries, laparoscopic exploration has limitations. Certainly, the hemodynamically unstable patient, who requires rapid hemostasis and restoration of circulating blood volume, is not a candidate for laparoscopic exploration. The use of gravity (i.e. reverse Trendelenburg Position and steep lateral rotation) to move the viscera can have detrimental effects in an already hemodynamically compromised patient.

Tactile sensation is greatly diminished, although not eliminated (1). Manipulating structures with small instruments through a trocar rather than by direct tissue contact with the surgeon's hand may be misleading. Palpation of the posterior-lateral aspect of the liver and the posterior-superior aspect of the spleen, for example, is often an easy way to detect injuries of these solid organs. Direct visualization of theses surfaces with the laparoscope must be accomplished in order to avoid missing an injury. This task can be difficult laparoscopically unless the surgeon is facile with two-handed dissection and the use of an angled laparoscope.

The laparoscope itself adds another constraint to the procedure. What is usually viewed and handled as a three dimensional structure is converted to a flat image on a monitor screen remote from the patient's body. This makes manipulation of instruments and tissue difficult and imprecise due to the lack of depth perception. If there is active bleeding, the image can be easily obscured by blood splattered on the lens and hemoglobin in the shed blood absorbs transmitted light, thus limiting the clarity of the image.

Laparoscopic surgery is highly dependent on technology. The equipment necessary to perform laparoscopy employs computers, electronics and delicate circuits that are susceptible to failure. The failure of one component can render the whole procedure unworkable. This point is illustrated by the bulb failure in the light source. All the potential benefits of successful laparoscopic exploration are eliminated by the inability to illuminate the peritoneal cavity. This point emphasizes the importance of having a dedicated team who are not only familiar with the surgical procedures, but also are versed in trouble-shooting the equipment used during the operation.

Although laparoscopy is less invasive than laparotomy, it is not without its own procedure-related morbidity. Risks of laparoscopic exploration for trauma are the same as for elective laparoscopy. A recent report cited a 1% procedure-related complication rate (2). Procedure-related injuries included tension pneumothorax, small bowel injury, abdominal vascular injury, epigastric artery trocar injury, trocar injury to the small bowel, omental vessel injury and CO_2 insufflation in the extra-peritoneal space. Iatrogenic injuries must be avoided in order not to compromise the benefits of this less invasive operation. Tension pneumothorax can be avoided by using gasless laparoscopy, lowering the intra-abdominal pressure and inspecting the diaphragm first. The incidence of small bowel and vascular injuries can be reduced by careful handling of tissues with atraumatic graspers and by inserting all trocars under direct visualization in areas away from the course of known vessels.

Perhaps the greatest pitfall of laparoscopic exploration for trauma is failing to detect injuries which, as a consequence, go untreated. Although injuries to any organ in the abdomen can be missed, hollow viscus injury is of greatest concern. Because of the convoluted surface of the bowel and the difficulties in mobilization, a small perforation may go undetected with dire consequences for the patient. Complications & mortality are directly related to diagnostic delays (3).

When discussing both the potential pitfalls and promises of laparoscopic exploration for trauma, it is important to understand the goals of the procedure. Laparoscopy can be divided into three categories based on the objective of the procedure: 1) screening - searching for an indication to proceed to laparotomy by confirming peritoneal penetration, 2) diagnostic - defining all abdominal injuries and 3) therapeutic - diagnosing and treating all injuries.

The reported rate of missed injuries is 1% when used as a screening technique but ranges from 41% to 77% when laparoscopy is used as a diagnostic tool (4,5). If an

injury is missed, the increase in morbidity and mortality may eliminate the benefits of this procedure.

PROMISES

Some of the benefits observed in elective laparoscopic procedures have been realized in emergent cases as well. A negative laparoscopic exploration decreases length of stay and reduces cost when compared to negative laparotomy. This has the potential to be a great advantage to trauma centers which care for a large proportion of uninsured patients (6,7,8,9,10,11). Other potential patient benefits include earlier return to normal activities, earlier return to work, reduced pain and less scarring.

Screening laparoscopy is primarily used in penetrating trauma to assess for violation of the peritoneal cavity. This has proven to be one of the best uses of laparoscopy for trauma. In their review of this subject, Villavicencio and Aucar examined both retrospective and prospective data (2). They found screening laparoscopy had a sensitivity of 93% to 100%, a specificity of 80% to 100%, and an accuracy of 84% to 100%. Prospective reports that were reviewed in that same study showed a sensitivity of 85% to 100%, a specificity of 73% to 100% and an accuracy of 80% to 100%. Their review of screening laparoscopy for blunt trauma showed similar results (Table 1) .

Diagnostic laparoscopy has proven to be more problematic. By definition, diagnostic laparoscopy seeks to identify all injuries in the abdomen. The results reported in the literature have been less encouraging. The rate of missing important injuries which, by protocol, were later discovered at a mandatory laparotomy has been as high as 77%. (C) This number of missed injuries, had they gone untreated, would have no doubt led to increased morbidity and mortality, eliminating any potential benefits.

Therapeutic laparoscopy not only requires definition of all injuries, but includes the capability to treat them as well. When the injuries are limited primarily to the diaphragm and solid organs, this modality has proven to be useful (10). Therapeutic laparoscopy has two limitations: the unreliability of diagnostic laparoscopy and the surgeon's laparoscopic skills and ability to perform laparoscopic repair of detected injuries.

The greatest benefit to be gained from laparoscopy in trauma is the avoidance of a nontherapeutic laparotomy, truly a diagnostic operation which has a morbidity rate approaching 50% and a reported length of stay of 8 days (12). However, the ideal strategy to prevent unnecessary celiotomy, yet avoid missed injuries, remains to be defined. The proper selection of patients, a high index of suspicion, favorable injury pattern (i.e. penetrating thoracoabdominal injury), low threshold for converting to open operation, improved laparoscopic skills and patience on the surgeon's part all play a role in maximizing the benefits of laparoscopy in trauma (13).

TABLE 1 - PROSPECTIVE STUDIES EVALUATING SCREENING LAPAROSCOPY (2).

	Screening-Blunt	Screening-Penetrating
Sensitivity (%)	90-100	85-100
Specificity (%)	86-100	73-100
Accuracy (%)	88-100	80-100

BIBLIOGRAPHY

1. *Bholat OS, Haluck RS, Murray WB, et al. Tactile feedback is present during minimally invasive surgery. J Am Coll Surg, 1999;189:349-355.*

2. *Villavicencio RT, Aucar JA. Analysis of laparoscopy in trauma. J Am Coll Surg, 1999;189:11-20.*

3. *Brownstein MR, Bunting T, Meyer AA, Fakhry SM: Diagnosis and management of blunt small bowel injury. J Trauma, 2000; 402-407.*

4. *Rossi P, Mullins D, Thal E. Role of laparoscopy in the evaluation of abdominal trauma. Am J Surg, 1993;166:707-711.*

5. *Mazuski JE, Shapiro MJ, Kaminski DL, et al. Diagnostic laparoscopy for evaluation of penetrating abdominal trauma. J Trauma, 1997;42:163.*

6. *Fabian TC, Croce MA, Stewart RM, et al. A prospective analysis of diagnostic laparoscopy in trauma. Ann Surg, 1993;217:557-565.*

7. *Dalton JM, Demaria EJ, Gore DC, et al. Prospective evaluation of laparoscopy in abdominal stab wounds [Abstract]. J Trauma, 1994;36-149.*

8. *Sosa JL, Baker M, Puente I, et al. Negative laparotomy in abdominal gunshot wounds: potential impact of laparoscopy. J Trauma, 1995;38:194-197.*

9. *Ditmars ML, Bongard F. Laparoscopy for triage of penetrating trauma: the decision to explore. J Laparoendosc Surg, 1996;6:285-291.*

10. *Marks JM, Youngelman DF, Berk T. Cost analysis of diagnostic laparoscopy versus laparotomy in evaluation of penetrating abdominal trauma. Surg Endosc, 1997;11:272-276.*

11. *Smith RS, Tsoi EKM, Fry WR, et al. Laparoscopy is cost effective in the evaluation of abdominal trauma [Abstract]. Surg Endosc, 1993;7:137.*

12. *Renz BM, Feliciano DV. The length of hospital stay after an unnecessary laparotomy for trauma: a prospective study. J Trauma, 1996;40:187.*

13. *Zantut LF, Ivatury RR, Smith RS, et al. Diagnostic and therapeutic laparoscopy for penetrating abdominal trauma: a multicenter experience. J Trauma, 1997;42:825-831.*

RESECCIONES PULMONARES EN TRAUMA

Rafael Andrade-Alegre, FACS, FCCP

RESUMEN

Las resecciones pulmonares (neumonectomía y lobectomía) en trauma son poco frecuentes pero tienen una morbilidad y mortalidad muy elevada. La neumonectomía en pacientes en shock hemorrágico conlleva con frecuencia a falla ventricular irreversible.

Estos pacientes deben ser abordados con técnicas de control de daños como el pinzamiento y división en masa del hilio pulmonar. En lesiones profundas del parénquima pulmonar, pero que no afectan el hilio, la tractotomía es una técnica muy útil y gratificante.

Palabras clave

Trauma de tórax, Neumonectomía, Lobectomía, Tractotomía.

SUMMARY

Pulmonary resections (pneumonectomy and lobectomy) in trauma are infrequent but they have a high morbidity and mortality. Pneumonectomy in patients with hemorrhagic shock involves frequently irreversible ventricular failure. These patients should be approached with damage control techniques such as clamping and mass division of the pulmonary hilum. In deep parenchymal lesions that do not affect the hilum, tractotomy is a very useful and rewarding technique.

Sección de Cirugía Torácica, Hospital Santo Tomas Panamá. República de Panamá.

Keywords

Thoracic trauma, Pneumonectomy, Lobectomy, Tractotomy.

ANTECEDENTES HISTÓRICOS

La Iliada de Homero es un tratado de trauma militar. Se ha podido calcular que las heridas torácicas tenían una mortalidad de 92 %. El tratamiento de las heridas torácicas fue muy básico por cientos de años. Paré recomendaba que si había poco sangrado en una herida torácica ésta debía cerrarse. Larrey, cirujano de Napoleón, por su parte recomendada que si se oía el sonido del aire con las respiraciones del paciente, entonces la herida debía cerrarse. Esta controversia continuaría hasta el siglo XX (1). Fue a Rolandus a quien se le atribuye la primera resección pulmonar (no anatómica) aproximadamente en el año 1383. Rolandus resecó un segmento de parénquima pulmonar necrótico y herniado a través de una herida de en la pared torácica. El paciente sobrevivió (2). Pasaron casi 600 años para que se realizara la primera neumonectomía exitosa. Correspondió el mérito a Rudolph Nissen en 1931 (3). Nissen operó a una niña de 12 años que había sufrido trauma torácico por aplastamiento un año antes, desarrollando múltiples infecciones pulmonares, bronquiectasias y estenosis del bronquio principal izquierdo. La cirugía la realizó en dos tiempos quirúrgicos y ligó en masa el hilio pulmonar.

INCIDENCIA

Las toracotomías abiertas asociadas a trauma oscilan en diversas series entre el 7 y 16% (4-6). Las resecciones pulmonares mayores es decir neumonectomías y lobectomías ocupan solamente un rango entre 2 y 16%

de todas las toracotomías por trauma (4,5,7-10). En la experiencia personal del autor esta relación está en 3.1% (5/161). Esto significa que en la mayoría de los casos de trauma pulmonar las heridas pueden resolverse con otros procedimientos.

SITUACIÓN ACTUAL DE LAS RESECCIONES EN TRAUMA

La morbi-mortalidad de las resecciones pulmonares mayores en trauma es muy elevada. La mortalidad para las lobectomías oscila entre el 11 y 66% y para las neumonectomías está entre el 50 y 100% (4,5,7-10). En las neumonectomías no traumáticas hay una serie de factores que se asocian a morbilidad y mortalidad perioperatoria. Uno de estos factores es la intubación selectiva que previene la contaminación con sangre o pus del pulmón no operado y además facilita la exposición y la cirugía. El otro factor es la restricción de líquidos en el trans-operatorio y post-operatorio (11). Estos pacientes están propensos a desarrollar edema pulmonar no cardiogénico y la administración excesiva de cristaloides o sangre pueden precipitar esta condición. Estos mismos factores parecen tener una influencia determinante en las resecciones pulmonares mayores por trauma, específicamente en la neumonectomía. No es fácil realizar intubaciones selectivas en pacientes que llegan al cuarto de urgencias en mal estado general, donde es necesario controlar la via aérea de forma prácticamente inmediata y que muchas veces necesitan una toracotomía de resucitación. Por otro lado, las resecciones pulmonares en trauma se deben en la gran mayoría de los casos a hemorragia masiva (84 al 93 % de los casos). La indicación en el resto de los pacientes está relacionada a lesiones bronquiales mayores (4,5,8,10). Estos pacientes requieren grandes volúmenes de líquidos (cristaloides y sangre) por lo que resulta fácil colegir que éste es un efecto deletéreo en el paciente sometido a neumonectomía. Parece haber un efecto sinergístico negativo: shock hemorrágico + neumonectomía. Este fenómeno ha sido estudiado por Cryer y col. (12) en animales: Utilizó tres grupos de animales: A. Se les produjo shock hemorrágico, B. Se realizó neumonectomía y C. Shock hemorrágico + neumonectomía. En los 3 grupos se presentó un aumento significativo de la presión media de la arteria pulmonar y de la resistencia vascular pulmonar. Estas anomalías fueron corregidas por los mecanismos compensatorios del corazón tanto para el grupo A como para el grupo B, no así para el grupo C. En el grupo del shock hemorrágico y neumonectomía al no ocurrir la compensación del ventrículo derecho, hay una disminución de la fracción de eyección y del volumen de contracción ventricular produciendo finalmente falla ventricular irreversible. Estos hallazgos fueron apreciados por Cryer en sus pacientes y también han sido reportado por Bowling (7) y Baumgartner (13).

PROCEDIMIENTO QUIRÚRGICO

Estos pacientes deben ser manejados con técnicas de toracotomía abreviada o control de daños (14-16). Lo primero que se debe hacer es pinzar el hilio pulmonar (9). De esta manera se controla la hemorragia y a la vez se previene el embolismo aéreo. Inmediatamente se evalúa la causa del sangrado y se procede de acuerdo: tractotomía, resección en cuña/amputación periférica de parénquima pulmonar lesionado, lobectomía o neumonectomía. Cuando se ha decidido que el paciente requiere neumonectomía, debe también utilizarse un procedimiento abreviado como es la división del hilio en masa con autosuturas. Esto ahorra tiempo de forma muy significativa como lo ha reportado Wagner (17). También mejoró la sobrevida con esta técnica de control de daños. Otro método que se puede utilizar y que debe tenerse en cuenta es el control de los vasos hiliares de forma intrapericárdica.

Merece especial atención la tractotomía, una técnica de toracotomía abreviada, descrito en 1994 por Wall y col. (18) y luego modificada por Asensio y col. (19) haciéndola más versátil al incorporar el uso de autosuturas (tipo GIA). Esto acorta aún más el tiempo del procedimiento. La tractotomía es útil en heridas transfictivas del parénquima pulmonar pero que no afectan el hilio pulmonar. Con esta técnica se controlan los vasos sangrantes y las fugas aéreas. Este procedimiento puede evitar la realización de lobectomías y neumonectomías en algunos casos. Definitivamente tiene menor morbi-mortalidad como ha sido reportado por varios autores (20-22).

LO NUEVO

Se ha demostrado que una de las causas importantes de muerte en las neumonectomías por trauma es la

falla cardíaca derecha y el síndrome de insuficiencia respiratoria aguda (SIRA). El óxido nítrico se ha usado para estos pacientes con SIRA con buenos resultados al disminuir la hipertensión pulmonar. Nurozler (23) tuvo éxito en un caso de neumonectomía por trauma y SIRA utilizando el óxido nítrico. Por otro lado Cerfolio (24) ha publicado recientemente su experiencia con el solumedrol al momento de ligar la arteria pulmonar en neumonectomías no traumáticas. El resultado de este estudio, que incluyó 72 pacientes, mostró que 35 pacientes en que se utilizó solumedrol no se presentó ningún caso de SIRA. De los 37 pacientes sin uso de solumedrol, hubo 5 casos que presentaron esta complicación. Ambos tratamientos requerirán de estudios randomizados para valorar su utilidad.

BIBLIOGRAFÍA

1. *Bellamy R.: History of surgery for penetrating chest trauma. Chest Surg Clin North Am 2000; 10: 55-70.*

2. *Kittle C.: The history of lobectomy and segmentectomy including sleeve resection. Chest Surg Clin North Am 2000; 10: 105-130.*

3. *Fell S.: A history of Pneumonectomy. Chest Surg Clin North Am. 1999; 9: 267-290.*

4. *Tominaga G, Waxman K, Sacnnell G, et al.: Emergency thoracotomy with lung resection following trauma. Am Surg 1993; 59: 834-837.*

5. *Stewart K, Urschel J, Nakai S, et. L.: Pulmonary resection for lung trauma. Ann Thorac Surg 1997; 63: 1587-8.*

6. *Gasparri M, Karmy-Jones R, Kralovich K, et.al.: Pulmonary tractotomy versus lung resection: viable options in penetrating lung injury. J Trauma 2001;51: 1092-1097.*

7. *Bowling R, Mavroudis C, Richardson J, et.al.: Emergency pneumonectomy for penetrating and blunt trauma. Am Surg 1985; 51: 136-9.*

8. *Thompson D, Rowlands B, Walker W, et.al.: Urgent thoracotomy for pulmonary or tracheobronchial injury. J Trauma 1988; 28: 276-80.*

9. *Wiencek R, Wilson R.: Central lung injuries: a need for early vascular control. J Trauma 1988; 28: 1418-24.*

10. *Carrillo E, Block E, Zeppa R, Sosa J.: Urgent lobectomy and pneumonectomy. Eur J Emerg Medicine 1994; 1: 126-30.*

11. *Naunheim K.: Postoperative care and monitoring. Chest Surg Clin North Am 1999; 9: 501-13.*

12. *Cryer H, Mavroudis C, Jun Y, et.al.: Shock, transfusion, and pneumonectomy. Ann Surg 1990; 212: 197-201.*

13. *Baumgartner F, Omari F, Bleiweis M, et.al.: Survival after trauma pneumonectomy: the pathophysiologic balance of shock resucitation with right heart failure. Am Surg 1996;62: 967-72.*

14. *Wall M, Soltero E.: Damage control for thoracic injuries. Surg Clin North Am 1997; 77: 863-78.*

15. *Mashiko K, Matsumoto H, Mochizuki T, et.al.: Damage control for thoracic injuries. Nippon Geka Gakkai Zasshi 2002; 103: 511-6.*

16. *Wilson A, Wall M, Maxson R, Mattox K: The pulmonary hilum twist as a thoracic damage control procedure. Am J Surg 2003; 186: 49-52.*

17. *Wagner J, Obeid F, Karmy-Jones R, et.al.: Trauma pneumonectomy revisited: the role of simultaneously stapled pneumonectomy. J Trauma 1996; 40: 590-4.*

18. *Wall M, Hirshberg A, Mattox K.: Pulmonary tractotomy with selective vascular ligation for penetrating injuries to the lung. Am J Surg 1994; 168: 665-9.*

19. *Asensio J, Demetriades D, Berne J, et.al.: Stapled pulmonary tractotomy: A rapid way to control hemorrage in penetrating pulmonary injuries. J Am Coll Surg 1997; 185: 504-5.*

20. *Wall M, Villavicencio R, Miller C, et.al.: Pulmonary tractotomy as an abbreviated thoracotomy technique. J Trauma 1998; 54: 1015-23.*

21. *Velmahos G, Baker C, Demetriades D, et.al.: Lung-sparing surgery after penetrating trauma using tractotomy, partial lobectomy, and pneumorrhaphy. Arch Surg 1999; 134: 186-9.*

22. *Cothren C, Moore E, Biffl W, et.al.: Lung-sparing techniques are associated with improved outcome compared with anatomic resection for severe lung injuries. J Trauma 2002; 53: 483-7.*

23. *Nurozler F, Argenziano M, Ginsburg M.: Nitric oxide usage after posttraumatic pneumonectomy. Ann Thorac Surg 2001; 71: 364-6.*

24. *Cerfolio R, Bryant A, Thurber J, et.al.: Intraoperative solumedrol helps prevent postpneumonectomy pulmonary edema. Ann Thorac Surg 2003: 76: 1029-35.*

TRAUMA CARDÍACO PENETRANTE

Rafael Andrade-Alegre, FACS, FCCP

RESUMEN

El tratamiento del trauma cardíaco penetrante ha evolucionado con el correr de los años. Los cambios significativos en la sobrevida se deben a un transporte más rápido y a un diagnóstico y tratamiento agresivo.

La utilización de las escalas de trauma ha permitido evaluar los diferentes reportes en la literatura, comparar los resultados y establecer la probabilidad de sobrevida.

Palabras clave

Trauma cardíaco, Toracotomía, Ventana pericárdica, misiles intracardíacos

SUMMARY

The treatment of penetrating cardiac trauma has evolved through the years. The most significant changes in patients survival are due to a faster transportation and to an aggressive diagnosis and treatment.

The use of trauma scales has allowed for the evaluation of reports in medical literature, compare results, and establish the probability of survival.

Keywords

Cardiac trauma, Thoracotomy, Pericardial window, cardiac missiles

Sección de Cirugía Torácica, Hospital Santo Tomas Panamá. República de Panamá.

NOTAS HISTÓRICAS

Por siglos se consideró que las heridas cardíacas eran mortales. Así lo escribió Hipócrates (460-377 a.c.). Aristóteles (384-322 a.c.) fue aún más específico cuando dijo “el corazón es la única víscera que no puede tolerar ninguna afección seria”.

Celso (Siglo I de la era cristiana), quien es considerado el escritor del primer tratado de Medicina y Cirugía describe que es imposible salvar a los pacientes con heridas cardíacas. Más adelante Galeno (131-200) ratifica que las heridas cardíacas son fatales. El describe las heridas cardíacas de los gladiadores. Estos conceptos sobre la mortalidad de las heridas cardíacas continúa hasta el siglo XIX. (1). Las heridas cardíacas se manejaban de forma “conservadora”: aplicación de sanguijuelas, venodisecciones y en otros casos colocación de catéteres a través de la herida para drenar el líquido de la cavidad pleural. El Barón Larrey, cirujano de Napoleón, describió en 1829 su experiencia con las heridas cardíacas y la pericardiotomía para drenaje de efusiones pericárdicas (2).

El inicio de la sutura de las heridas cardíacas tiene lugar con Block, quien en 1882 realiza experimentos en conejos suturando heridas cardíacas en forma exitosa (3). Sin embargo esto fue poco apreciado en la época. Al gran cirujano vienés Theodor Billroth se le han atribuido frases muy fuertes en contra del manejo de las heridas cardíacas entre 1880 y 1883: “El cirujano que intente suturar una herida cardíaca deberá perder el respeto de sus colegas” y “Que ningún hombre se atreva a operar el corazón”(4). Habiendo dicho esto hay quienes ponen en duda que Billroth hubiese hecho tales comentarios (5,6).

Fue Ludwig Rehn en Frankfurt quien en 1897 publica el caso de la primera cardiorrafia exitosa en un humano y con esto inicia la era de la cirugía cardíaca (7). L. Hill en 1902, realiza la que se podría considerar la primera toracotomía de resucitación en un joven de 13 años con herida por arma blanca en el corazón. Esta operación la realizó en Montgomery, en la mesa de una cocina y alumbrado por dos lámparas de kerosene! (8).

Como en muchos aspectos de la medicina el péndulo se ha movido hacia atrás y el trauma cardíaco no fue la excepción. La elevada morbilidad de la toracotomía por la falta de adecuada anestesia, analgésicos, falta de antibióticos y adecuados cuidados post-operatorios favoreció otros procedimientos menos invasivos que inicialmente paracieron ser muy efectivos como lo es la pericardiocentesis. Uno de los artículos más influyentes en este sentido fue el artículo de Blalock y Ravitch de Johns Hopkins (1943) relatando el éxito del tratamiento de heridas cardíacas por arma blanca mediante pericardiocentesis (9). La controversia continuó por varios años hasta que aparecieron los trabajos del Beall (10,11,12) y Sugg (13). El aumento de las heridas por proyectil de arma de fuego, el transporte más rápido de los pacientes, la organización de los servicios de trauma y la mayor seguridad de la toracotomía definieron de una vez por todas el mejor tratamiento para las heridas cardíacas: la toracotomía y cardiorrafia.

DEMOGRAFÍA DEL TRAUMA CARDÍACO PENETRANTE

Para estudiar el trauma cardíaco penetrante se deben tener en cuenta una serie de factores que se relacionan con la morbi-mortalidad: aspectos sociales, mecanismo de la lesión, atención prehospitalaria, diagnóstico y tratamiento.

La demografía social muestra incidencias del trauma cardíaco penetrante diametralmente opuestas en diversas ciudades y esto a su vez depende de varios factores. Por ejemplo en Los Angeles, Estados Unidos, Asensio y col. reportan 105 casos con heridas cardíacas por trauma penetrante en solo 2 años (14). Rashid y col. en Gothenburg, Suecia reportan 7 casos en 10 años (15). Estas diferencias se deben a múltiples factores como son la educación y nivel económico de la población involucrada, el pandillerismo, la ingesta de alcohol y/o drogas, el narcotráfico, la violencia intrafamiliar. Así mismo el mecanismo de la lesión es determinante: las heridas por proyectil de arma de fuego tienen una mortalidad mucho mayor que las heridas por arma blanca (16-20). Esto se debe a que las heridas por proyectil de arma de fuego producen un daño mayor en el miocardio, se taponan menos y producen lesiones múltiples en un mayor porcentaje (21). El taponamiento cardíaco se ha considerado como un efecto "protector" al evitar un sangrado masivo. Este hallazgo lo han reportado consistentemente varios autores (22-26). Buckman (27) y Asensio (28) no encontraron esta relación.

La atención prehospitalaria que incluye por supuesto, el tiempo de transporte al hospital tiene una importancia muy significativa en la mortalidad de estos pacientes (19,29-35). Al mejorar el transporte de estos pacientes al hospital, llegarán más pacientes en estado crítico que podrán ser tratados (36-38). Anteriormente la evolución natural era la muerte de muchos de estos pacientes en la escena del trauma.

El otro aspecto determinante es un diagnóstico y tratamiento expedito.

La mayoría de estos pacientes llegan a los cuartos de urgencias inestables, en extremis y requieren de cirugía inmediata. Desde el establecimiento de la toracotomía de resucitación o toracotomía del cuarto de urgencias se ha acumulado numerosa información que revela que son precisamente las heridas cardíacas las que tienen mejor sobrevida. Rhee y col.(39) revisaron 24 estudios y un total de 4,620 pacientes con trauma. Se encontró que las heridas cardíacas tienen la mejor sobrevida en la toracotomía de resucitación: 19.4%. Un grupo de trabajo del Comité de Trauma del Colegio Americano de Cirujanos en una revisión de 46 trabajos sobre trauma cardiaco penetrante encontró una sobrevida de 31.1% (40).

CUADRO CLÍNICO Y DIAGNÓSTICO

La presentación clínica de los pacientes con trauma cardíaco penetrante depende de 2 consecuencias de la herida: taponamiento cardíaco o sangrado masivo. Alrededor del 60 al 80 % de los pacientes con heridas cardíacas fallecen antes de llegar al hospital (21,41).

De los pacientes que llegan con vida la mayoría están inestables (signos obvios de taponamiento cardíaco o con sangrado masivo) y son operados rápidamente. El resto, aproximadamente un 20% llegan "estables" y sin signos o síntomas obvios de herida cardíaca (42). La presencia de herida en la "zona de peligro" de Sauer y Murdoch indica la necesidad de descartar herida cardíaca (43). En estos pacientes la clásica tríada de Beck del taponamiento cardíaco se encuentra en un bajo porcentaje como ya ha sido reportado (22,44). En cuanto a los estudios de gabinete, la radiografia de tórax es de poca ayuda (45,46). El electrocardiograma tampoco ha sido muy útil. En la mayoría de los casos se presentan cambios inespecíficos (42). Los signos de lesión cardíaca están asociados a lesiones de las coronarias y estas ocurren alrededor del 3% al 6% (22,47). La determinación de la presión venosa central en el cuarto de urgencias presenta un alto porcentaje de error (falsos positivos) y esto se debe a varios factores: los pacientes pueden haber sido resucitados muy vigorosamente, la colocación del catéter puede ser inadecuada y los pacientes con frecuencia realizan maniobras de Valsalva. Duncan y col. (48) no encontraron diferencias en las mediciones de la presión venosa central de los pacientes con y sin herida cardíaca. Es importante mencionar el riesgo de iatrogenia al colocar catéter central en estos pacientes que muchas veces están combativos y poco cooperadores por los efectos de las drogas y el alcohol. La pericardiocentesis tampoco ha pasado la prueba del tiempo como método diagnóstico ni terapéutico (49). Existen reportes con altas incidencias de falsos positivos y falsos negativos. Estos últimos son los más peligrosos pues dan una sensación falsa de seguridad (13,50-52). La pericardiocentesis tiene cabida hoy día en el taponamiento cardíaco como medida salvadora en pacientes inestables y que no pueden ser operados inmediatamente.

La ventana pericárdica subxifoidea como método diagnóstico de las heridas cardíacas fue popularizada por Kit Arom (53) en 1977 y tuvo gran auge en la década del 80 y 90. Sus ventajas son la rapidez, precisión y seguridad de la técnica para el diagnóstico de heridas cardíacas en pacientes "estables" (42,48,49,51,52,54-56). Su aspecto negativo es que es un procedimiento invasivo y cuya positividad se encuentra entre el 15 y el 28% de los procedimientos realizados. A finales de la década del 80 y comienzos del 90 se comenzó a utilizar el ecocardiograma (57,58) para detectar sangre en el pericardio y actualmente podríamos decir que es el "standard de oro" como método diagnóstico en el trauma cardíaco penetrante pués es extremadamente rápido, confiable, no invasivo, barato y repetible. (59-62). Este procedimiento implica que el equipo debe estar disponible las 24 horas del día y es dependiente del operador. El dejar el estudio para después porque el paciente se encuentra "estable" violaría los principios del manejo del trauma al diferir el diagnóstico de una lesión potencialmente fatal. Finalmente otra técnica quirúrgica para el diagnóstico de las heridas cardíacas es la toracoscopía. Graeber (63) en 1993 indicaba que la toracoscopía podía ser de utilidad en el diagnóstico y tratamiento del trauma torácico, incluyendo el trauma cardíaco. Morales y col. en Colombia presentaron una serie de 108 ventanas pericárdicas toracoscópicas con sensibilidad de 100%, especificidad de 96% y certeza de 97% (64). Además, el procedimiento permitió la evaluación de otras lesiones torácicas y evacuación del hemotórax. Un reporte similar de Pons y col. (65) también utiliza la toracoscopia para descartar lesión cardíaca, evaluación del diafragma, evacuación de hemotórax, hemostasia de laceraciones de vasos de la pared y sutura del laceraciones pulmonares. Esta sería una indicación muy precisa y útil en casos de sospecha de herida cardíaca y otras lesiones, sin embargo, en caso de no haber penetración a la cavidad pleural, más rápido, menos invasivo y menos costoso sería el ecocardiograma o la ventana pericárdica subxifoidea.

Durante al evaluación inicial los pacientes se dividen en 3 grupos:

a. Aquellos en arresto cardíaco o arresto cardíaco inminente con trauma penetrante que requerirán una toracotomía de resucitación, evidentemente sin ningún estudio diagnóstico.
b. Pacientes con hipotensión severa requieren cirugía de urgencia en el salón de operaciones, sin ninguna investigación específica. Si el estudio está disponible inmediatamente y no hay retrasos, se puede realizar ultrasonido y radiografías de tórax y abdomen. (Especialmente en casos donde la causa de la hipotensión no está clara, como múltiples heridas en el tronco).
c. Pacientes estables. Estos pacientes se benefician de estudios que pueden tomar más tiempo (66).

ABORDAJE QUIRÚRGICO

En los pacientes inestables la incisión más utilizada es la toracotomía anterior izquierda. El instrumental para este abordaje es muy sencillo (67). Esta incisión puede realizarse en menos de un minuto y permite aliviar el taponamiento cardíaco, controlar la hemorragia y dar masaje cardíaco directo (13,41). Además permite el pinzamiento de la aorta para redistribuir la sangre a los vasos coronarios y cerebro y a la vez reducir la pérdida sanguínea por lesiones en el tronco inferior (68). La desventaja de la toracotomía anterior izquierda puede ser la exposición, pero esto se corrige mediante la extensión transesternal e incluso realizando toracotomía bilateral (clamshell). La toracotomía derecha de forma inicial se indica en casos de hemotórax derecho masivo pero sin arresto cardíaco. En los casos de pacientes estables y trauma anterior se realiza esternotomía mediana ya que ofrece una mejor exposición (69).

CONTROL Y REPARACIÓN DE LAS HERIDAS CARDÍACAS

Para reparar las heridas cardíacas se han desarrollado una serie de maniobras: Primeramente se debe abrir el pericardio ampliamente y colocar el dedo sobre el punto sangrante. Las suturas se colocan en forma de U y se refuerzan con parches de teflón o pericardio para evitar desgarrar el músculo cardíaco, especialmente en el cirujano no familiarizado con estas heridas. Ocasionalmente, en heridas grandes o poco accesibles es necesario producir una oclusión total del flujo sanguíneo al corazón pinzando la vena cava superior e inferior (28). Heridas en los atrios, vena cava y aorta frecuentemente se pueden controlar colocando pinzas vasculares, también se puede usar una sonda Foley inflando el balón y traccionándolo contra la pared del atrio o vaso sangrante. La sonda Foley también puede usarse para heridas ventriculares y para administrar líquidos (70). Las heridas posteriores son difíciles de suturar, en estos casos se puede colocar una pinza Satinsky en el ángulo del ventrículo derecho y traccionar el corazón hacia delante y así poder colocar las suturas (71). En casos de pacientes sometidos a toracotomía de resucitación se puede hacer un cierre temporal de la herida cardíaca utilizando grapas (72). Lim (73) reporta el uso de la adenosina para facilitar la cardiorrafia al producirse una corta asistolia.

La reparación de heridas cerca de las arterias coronarias tiene implicaciones especiales. Las suturas deben colocarse por debajo de la arteria y así evitar ligarla lo que produciría un infarto. Habiendo dicho esto, las arterias más distales, por ejemplo: en caso de la arteria coronaria descendente anterior, las ramas distales a la primera septal perforante pueden ser ligadas. Lesiones más proximales tendrían preferiblemente que ser reparadas con la ayuda de bypass cardiopulmonar, facilidad esta que no está disponible en los hospitales generales de forma rutinaria (74). Reissman y col. (75) en una revisión de reportes de heridas de las arterias coronarias, no encontró mayor diferencia entre las ligadas y las reparadas con ayuda de bypass cardiopulmonar. Recomienda que el bypass coronario sea utilizado solamente en los casos de heridas proximales de las arterias coronarias. Opinión similar ha sido reportada por Karin et. al (76). Otras alternativas serían la revascularización fuera de bomba (77) y la colocación de shunt intraluminal (78).

PROYECTILES INTRACARDÍACOS

Una situación poco frecuente en el trauma cardiaco penetrante lo son los proyectiles intracardíacos. No obstante, su manejo ha sido motivo de controversia a través de los años. Hay quienes abogan por un manejo conservador, mientras otros recomiendan que estos proyectiles sean removidos. Los que abogan por remover los proyectiles lo hacen basados en las posibles complicaciones como pueden ser erosión, infección o migración. Un artículo muy importante a este respecto fue el de Bland (79) quien siguió por 20 años a 40 soldados de la segunda guerra mundial con heridas cardíacas y proyectiles fijos en el miocardio. En ninguno de los pacientes se encontró erosión, infección o migración del proyectil. Estas complicaciones son muy infrecuentes con proyectiles fijos en el miocardio. Varios autores coinciden en las guías para decidir a quien se debe remover el proyectil y a quien no. Este manejo se podría resumir de la siguiente manera:

1. Tamaño y forma del proyectil: Aquellos con forma regular y no más grandes que una bala calibre 38 puede ser manejado conservadoramente.
2. Localización: Aquellos fijos en el miocardio o libres en las cavidades derechas (a excepación de aquellos que atraviesan víscera hueca) pueden ser manejados conservadoramente. Proyectiles libres o parcialmente

incorporados en las cavidades izquierdas o cerca de una arteria deberán ser extraidos. (80-83).

También es correcto decir que cuerpos extraños libres en las cavidades cardíacas pueden ser removidos mediante técnicas de radiología intervencionista si ésta está disponible. En centros con la facilidad para localizar los proyectiles mediante ecocardiografía intraoperaoria (84), éstos pueden extraerse de forma electiva (85).

SECUELAS

Las secuelas de una herida cardíaca oscilan entre 4 y 56%. Los síntomas que presentan los pacientes son aquellos de falla cardíaca congestiva, tienen soplos importantes o síntomas de taponamiento o pericarditis constrictiva (86). El siguimiento básico de una herida cardíaca debe incluir examen físico, EKG y una radiografía de tórax. Si se presenta alguna anormalidad entonces debe realizarse ecocardigrama pues es de mucha utililidad para investigar anormalidades valvulares, funcionamiento de las cavidades, presencia de efusión pericárdica etc (87,88). Algunos autores consideran que el ecocardiograma debe realizarse en todos los pacientes con heridas cardíacas (89). Un resultado anormal de ecocardiograma puede indicar la necesidad de algún procedimiento quirúrgico o la realización de otros estudios como caterización cardíaca para decidir conducta (90).

CONSIDERACIONES FINALES

El trauma cardíaco penetrante se ve cada vez con mayor frecuencia y esto se debe a un transporte más rápido y a un alto índice de sospecha diagnóstica seguido de un tratamiento agresivo. Particularmente el índice fisiológico descrito por Ivatury (91) es de gran ayuda para determinar, en los pacientes con sospecha de herida cardíaca, la rapidez con que debe ser tratado.

Existen cientos de artículos en la literatura médica sobre el trauma cardíaco penetrante donde la morbi-mortalidad es muy variable. En algunos casos la mortalidad ha sido tan baja que algunos autores han llegado a calificar las heridas cardíacas como "inocentes" (92). Los diferentes resultados se deben a una serie de factores muy particulares de cada hospital y de la población atendida con sus características como son la velocidad con que son traídos al hospital y el tipo de arma utilizada en la herida. La única manera de poder analizar los diferentes resultados es mediante la aplicación de las escalas de trauma. Entre éstas tenemos: la escala revisada de trauma (ERT), índice de severidad de las lesiones (ISS) y la escala cardiovascular-respiratoria (CVRS). Esta última es parte de la escala revisada de trauma (27).

Para apreciar en la práctica los beneficios de la aplicación de las escalas de trauma, comparamos los índices de trauma de 60 pacientes operados en el Centro de Trauma de LAC y USC de Los Angeles (93) con 51 pacientes operados en el Hospital Santo Tomás de Panamá. Las variables a analizar son edad, ERT, ISS y CVRS. (Ver Tabla 1 y 2). El ISS del grupo de pacientes de Los Angeles resultó mucho más alto que el de Panamá. Si tomamos en cuenta que el ISS máximo para una herida cardíaca es 25, vemos que este grupo de pacientes tuvo múltiples lesiones por lo elevado del ISS (37.3) y esto se correlaciona positivamente con un 58% de heridas por proyectil de arma de fuego que producen generalmente lesiones mayores y múltiples. Igualmente la ERT y el CVRS presentaron valores mucho más bajos para este mismo grupo de pacientes evidenciando que su condición fisiológica estaba muy comprometida, es decir, un porcentaje de estos pacientes estaban moribundos o incluso en arresto cardíaco. Estos valores claramente establecen el por qué estos pacientes tuvieron una mayor mortalidad operatoria (63.4% contra un 12%). Por otro lado de los valores encontrados en el grupo de Panamá podemos colegir que los pacientes operados llegaron en mejores condiciones lo que también sugiere que probablemente un porcentaje significativo de los pacientes fallece en la escena del trauma por falta de transporte rápido al hospital. En resumen, estos dos grupos de pacientes son muy diferentes y solo con la aplicación de los índices de trauma es que pueden analizarse las cifras y resultados. Podríamos concluir de esta revisión, que al conseguir la optimización del transporte de los pacientes con heridas cardíacas, así como un tratamiento agresivo, incluyendo la toracotomía de resucitación, obtendremos los límites más altos de sobrevida para estos pacientes. Quedaría entonces, dirigir nuestra atención hacia la prevención de estas desvastadoras heridas para lo que se requiere de mayores recursos para educación, mejorar el nivel económico de la población y llevar a cabo un mejor control de las armas, especialmente de fuego.

TABLA 1 - LOS ANGELES J AM COLL SURG 1998;186: 24-34. MORTALIDAD 63.4%

Variable	N	Media	Rango
Edad	60	28	6-58
RTS	50	2.14	0 - 7.84
CVRS	60	3.85	0 - 11
ISS	59	37.3	1 - 75

TABLA 2 - HOSPITAL SANTO TOMÁS, PANAMÁ. MORTALIDAD 63.4%

Variable	N	Media	Rango
Edad	51	26.25	16 - 49
RTS	51	5.96	2.1 - 7.84
CVRS	51	6.79	2 - 11
ISS	51	22.92	9 - 41

BIBLIOGRAFÍA

1. *Blatchford J, Anderson R. The evolution of the management of penetrating wounds of the heart. Ann Surg 1985; 202: 615-623.*

2. *Larrey D. New surgical procedure to open the pericardium in case of fluid in its cavity. Clin Chir 1829; 2:303-337.*

3. *Block M. Ueber wunden des herzens und ihre heilung durch die naht unter blutenleere. Verh Dtsch Ges Chir 1882; 11: 108-109.*

4. *Billroth T. Quoted from: Jeger E. Die Chirurgie der Blutgefasse und des herzens. Berlin. A Hirschwald, 1913.*

5. *McGoon D. The John Gibbon, Jr. Lecture. Bull Am Coll Surg. November 1982, p15.*

6. *Absolon K. Theodor Billroth and cardiac surgery. J Thorac Cardiovasc Surg 1983; 86:451-452.*

7. *Rehn L. Ueber penetrirende erzwunden und herznaht. Arch Klin Chir 1897;55:315-329.*

8. *Hill L. A report of a case of successful suturing of the heart, and table of 37 other cases of suturing by different operators with varios terminations, and the conclusions drawn. Medical Record 1902; 62:846-848.*

9. *Blalock A, Ravitch M. A consideration of the nonoperative treatment of cardiac tamponade resulting from wounds of the heart. Surg 1943; 14: 157-162.*

10. *Beall A, Oschner J, Morris G, et al. Penetrating wounds of the heart. J Trauma 1961; 1:195-207.*

11. *Beall A, Crosthait R, Crawford E, DeBakey M. Gunshot wounds of the chest: a plea for individualization. J Trauma 1964; 4:382-389.*

12. *Beall A, Diethrich E, Crawford H, et al. Surgical management of penetrating cardiac injuries. Am Surg 1966;112: 686-692.*

13. *Sugg W, Rea W, Ecker R. Penetrating wounds of the heart. An analysis of 459 cases. J Thorac Cardiovasc Surg 1968: 56: 531-544.*

14. *Asensio J, Berne J, Demetriades D, et al. One hundred 105 penetrating cardiac injuries: a 2-year prospective evaluation. J Trauma 1998;44:1073-1082.*

15. *Rashid M, Wikstrom T, Ortenwall P. Cardiac injuries: a ten year experience. Eur J Surg 2000;166(1):18-21.*

16. *Beall A, Patrick T, Okies J, et al. Penetrating wounds of the heart: Changing patterns of surgical management. J Trauma 1972; 12:468-473.*

17. *Naughton M, Brissie R, Bessey P, et al. Demography of penetrating cardiac trauma. Ann Surg 1989;6: 676-683.*

18. *Attar S, Suter C, Hankins J, et al. Penetrating cardiac injuries. Ann Thorac Surg 1991;51:711-716.*

19. *Henderson V, Smith S, Fry W, et al. Cardiac injuries: analysis of an unselected series of 251 cases. J Trauma 1994;36:341-348.*

20. *Mittal V, McAleese P, Young S, et al. Penetrating cardiac injuries. Am Surg 1999;65:444-448.*

21. *Ivatury R, Rohman M. The injured heart. Surg Clin North Am 1989; 69: 93-110.*

22. Demetriades D, van der Veen B. Penetrating injuries of the Heart: Experience over two years in South Africa. J Trauma 1983; 23: 1034-1041.

23. Moreno C, Moore E, Majure J, Hopeman A. Pericardial tamponade: A critical determinant for survival following penetrating cardiac wounds. J Trauma 1986; 26: 821-825.

24. Andrade-Alegre R, Moreno A, Ruiz-Valdés L. Trauma cardiaco penetrante. Rev Med Pan 1995; 20: 38-44.

25. Arreola-Risa C, Rhee P, Boyle, E et al. Factors influecing outcome in stab wounds of the heart. Am J Surg 1995;169: 553-556.

26. Tyburski J, Astra L, Wilson R, et al. Factors affecting prognosis with penetrating wounds of the heart. J Trauma 2000; 48: 587-591.

27. Buckman R, Badellino M, Mauro L, et al. Penetrating cardiac wounds: Prospective study of factors influencing initial resuscitation. J Trauma 1993; 34: 717-727.

28. Asensio J, Stewart M, Murray J, et al. Penetrating cardiac injuries. Surg Clin North Am 1996; 76: 785-719.

29. Kulshrestha P, Iyer S, Sampath K, et al. Cardiac injuries. A clinical and autopsy profile. J Trauma 1990; 30:203-207.

30. Rohman M, Ivatury R, Steichen F, et al. Emergency room thoracotomy for penetrating cardiac injuries. J Trauma 1983; 23: 570-576.

31. Esposito T, Jurkovich G, Rice C, et al. Reappraisal of emergency room thoracotomy in a changing environment. J Trauma 1991; 31:881-887.

32. Lorenz H, Steinmetz B, Lieberman J, et al. Emergency Thoracotomy: Survival correlates with physiologic status. J Trauma 1992:32: 780-788.

33. Durham L, Richardson R, Wall M, et al. Emergency center thoracotomy: Impact of prehospital resuscitation. J Trauma 1992; 32: 775-779.

34. Boyd M, Vanek V, Bourguet C. Emergency room thoracotomy: when is it indicated. J Trauma 1992; 33: 714-721.

35. Frezza E, Mezghebe H. Is 30 minutes the golden period to perform emergency room thoracotomy (ERT) in penetrating chest injuries? J Cardiovasc Surg 1999; 40: 147-151.

36. Arreola-Risa C, Mock C, Padilla D, et al. Trauma care systems in urban Latin America: the priorities should be prehospital and emergency room management. J Trauma 1995; 39: 457-462.

37. Mock C, Jurkovich G, nii-Amon-Kotei D, et al. Trauma mortality patterns in three nations at different economic levels: implications for global trauma system development. J Trauma 1998; 44: 804-812.

38. Ivatury R, Rohman M, Steichen F, et al. Penetrating cardiac injuries: twenty-year experience. Am Surg 1987; 53: 310-317.

39. Rhee P, Acosta J, Bridgeman A, et al. Survival after department thoracotomy: Review of published data from the last 25 years. J Am Coll Surg 2000; 190: 288-298.

40. Working group, Ad Hoc Subcommittee on Outcomes, Am Coll Surg-Committee on Trauma. J Am Coll Surg 2001;193: 303-309.

41. Mattox K, Beall A, Jordan G, De Bakey M. Cardiorrhaphy in the emergency center. J Thorac Cardiovasc Surg 1974; 68: 886-895.

42. Brewster S, Thirlby R, Zinder W. Subxiphoid pericardial window and penetrating cardiac trauma. Arch Surg 1988;123: 937-941.

43. Sauer P, Murdoch C. Inmediate surgery for cardiac and great vessel wounds. Arch Surg 1967; 95: 7-11.

44. Shoemaker W, Carey J, Yao S, et al. Hemodynamic alterations in acute cardiac tamponade after penetrating injuries of the heart. Surgery 1970; 67: 754-764.

45. Marshall W, Bell J, Kouchoukos N. Penetrating cardiac trauma. J Trauma 1984; 24: 147-149.

46. Symbas P. Cardiac Trauma. Am Heart J 1976; 92: 387-396.

47. Wall M, Mattox K, Chen C, Baldwin J. Acute management of complex cardiac injuries. J Trauma 1997; 42: 905-912.

48. Duncan A, Scalea T, Sclafani S, et al. Evaluation of occult cardiac injuries using subxiphoid pericardial window. J Trauma 1989; 29: 955-960.

49. Evans J, Gray L, Rayner A, Fulton R. Principles for the management of penetrating cardiac wounds. Ann Surg 1979; 189: 777-784.

50. Trinkle J, Toon R, Franz J, et al. Affairs of the wounded heart: Penetrating cardiac wounds. J Trauma 1979; 19: 467-472.

51. *Demetriades D. Cardiac wounds. Experience with 70 patients. Ann Surg 1986; 203: 315-317.*

52. *Miller F, Bond S, Shumate C, et al. Diagnostic pericardial window. Arch Surg 1987; 122: 605-609.*

53. *Arom K, Richardson D, Weeb G, et al. Subxiphoid pericardial window in patients with suspected traumatic pericardial tamponade. Ann Thorac Surg 1977; 23: 545-549.*

54. *Andrade-Alegre R, Mon L. Subxiphoid pericardial window in the diagnosis of penetrating cardiac trauma. Ann Thorac Surg 1994; 58: 1139-1141.*

55. *Ramírez M, Rodríguez J, Roa A. Trauma precordial. Heridas penetrantes del corazón. Rev Col Cirugía 1991; 6: 26-33.*

56. *Grewal H, Ivatury R, Divakar M, etal. Evaluation of subxiphoid pericardial window used in the detection of occult cardiac injury. Injury 1995;26:305-310.*

57. *Jiménez E, Martín M, Krukenkamp I, Barrett J. Subxiphoid pericardiotomy versus echocardiography: a prospective evaluation of the diagnosis of occult penetrating cardiac injury. Surgery 1990; 108: 676-680.*

58. *Freshman S, Wisner D, Weber C. Two-D echocardiography: emergent use in the evaluation of penetrating precordial trauma. J Trauma 1991; 31: 902-906.*

59. *Nagy K, Lohman C, Kim D, Barrett J. Role of echocardiography in the diagnosis of occult penetrating cardiac trauma. J Trauma 1995; 38: 859-862.*

60. *Rozycki G, Feliciano D, Schmidt J, et al. The role of surgeon-performed ultrasound in patients with posible cardiac wounds. Ann Surg 1996; 223: 737-746.*

61. *Rozycki G, Feliciano D, Ochsner M, et al. The role of ultrasound in patients with posible penetrating cardiac wounds: a prospective multicenter study. J Trauma 1999; 46: 543-552.*

62. *Carrillo E, Guinn B, Ali A, Boaz P. Transthoracic ultrasonography is an alternative to subxiphoid ultrasonography for the diagnosis of hemopericardium in penetrating precordial trauma. Am J Surg 2000; 179: 34-36.*

63. *Graeber J, Jones D. The role of thoracoscopy in thoracic trauma. Ann Thorac Surg 1993; 56: 646-648.*

64. *Morales C, Salinas C, Henao C, et al. Thoracoscopic pericardial window and penetrating cardiac trauma. J Trauma 1997; 42: 273-275.*

65. *Pons F, Lang-Lazdunski L, Kerangal X, et al. The role of videothoracoscopy in management of precordial thoracic penetrating injuries. Eur J Cardiothorac Surg 2002; 22: 7-12.*

66. *Demetriades D, Velmahos G. Penetrating injuries of the chest: Indications for operation. Scand J Surg 2002; 91: 41-45.*

67. *Schawb W, Adcock O, Max M. Emergency department thoracotomy (EDT). A 26 month experience using an agonal protocol. Am Surg 1986; 52: 20-29.*

68. *Dunn E, Moore E, Moore J. Hemodynamic effects of aortic occlusion during hemorragic shock. Ann Emerg Med 1982; 11: 238-241.*

69. *Mitchell M, Muakkassa F, Poole G, et al. Surgical approach of choice for penetrating cardiac wounds. J Trauma 1993; 34: 17-20.*

70. *Wilson S, Au F. In extremis use of a foley catheter in cardiac stab wound. J Trauma 1986; 26: 400-402.*

71. *Grabowski M, Buckman R, Goldberg A, Badellino M. Clamp control of the right ventricular angle to facilitate exposure and repair of cardiac wounds. Am J Surg 1995; 170: 399-400.*

72. *Shamoun J, Barraza K, Jurkovich G, Salley R. In extremis use of staples for cardiorraphy in penetrating cardiac trauma: case report. J Trauma 1989; 29: 1589-1591.*

73. *Lim R, Gill I, Temes R, Smith C. The use of adenosine for repair of penetrating cardiac injuries: A novel method. Ann Thorac Surg 2001;71:1714-1715.*

74. *Johnson S, Nielsen J, Sako E, et al. Penetrating intrapericardial wounds: Clinical experience with a surgical protocol. Ann Thorac Surg 1995; 60: 117-121.*

75. *Reissman P, Rivkind A, Jurim O, Simon D. Case report: The management of penetrating cardiac trauma with major coronary artery injury – is cardiopulmonary bypass essential? J Trauma 1992; 33: 773-775.*

76. *Karin E, Greenberg K, Avital S, et. al.. The management of stab wounds to the heart with laceration of the left anterior descending coronary artery. Eur J Emerg Med 2001; 8: 321-323.*

77. *Bowley D, Saeed M, Somwe D, et al. Off-pump cardiac revascularization after a complex stab wound. Ann Thorac Surg 2002;74: 2192-2193.*

78. Fedalen P, Bard M, Piacentino V, et al. Intraluminal shunt placement and off-pump coronary revascularization for coronary stab wound. J Trauma 2001;50: 133-135.

79. Bland E, Beebe G. Missiles in the heart: A twenty year follow up report of World War II cases. N Engl J Med 1966; 274: 1039-1046.

80. Symbas P, Vlais-Hale S, Picone A, Hatcher C. Missiles in the heart. Ann Thorac Surg 1989; 48: 192-194.

81. Ghandi S, Marts B, Mistry B, et al. Selective management of embolized intracardiac missiles. Ann Thorac Surg 1996; 62: 290-292.

82. Seipelt R, Vasquez-Jiménez J, Messmer B. Missiles in the heart causing coronary artery disease 44 years after injury. Ann Thorac Surg 2000: 70; 979-981.

83. Andrade-Alegre R, Saldaña B, Quirós R. Intracardiac missiles: should they be removed? Panam J Trauma 2002; 9: 77-80.

84. Font E, Gill C, Lammermier D. Echocardiographically guided removal of an intracardiac foreign body. Cleve Clin J Med 1994; 61: 228-231.

85. Poston R, Sloane R, Morgan B, et al. Elective removal of intramyocardial bullet. South Med J 2001; 94: 464-466.

86. Mattox K, Limacher M, Feliciano D, et al. Cardiac evaluation following heart injury. J Trauma 1985; 25: 758-765.

87. Duque H, Florez L, Moreno A, et al. Penetrating cardiac trauma: follow up study including electrocardiography, echocardiography, and functional test. World J Surg 1999; 23: 1254-1257.

88. Harris D, Janson J, Van Wyk J, et al. Delayed pericardial effusion following stab wounds to the chest. Eur J Cardiothorac Surg 2003; 23:473-476.

89. Cha E, Mittal V, Allaben D. Delayed sequelae of penetrating cardiac injury. Arch Surg 1993; 128: 836-841.

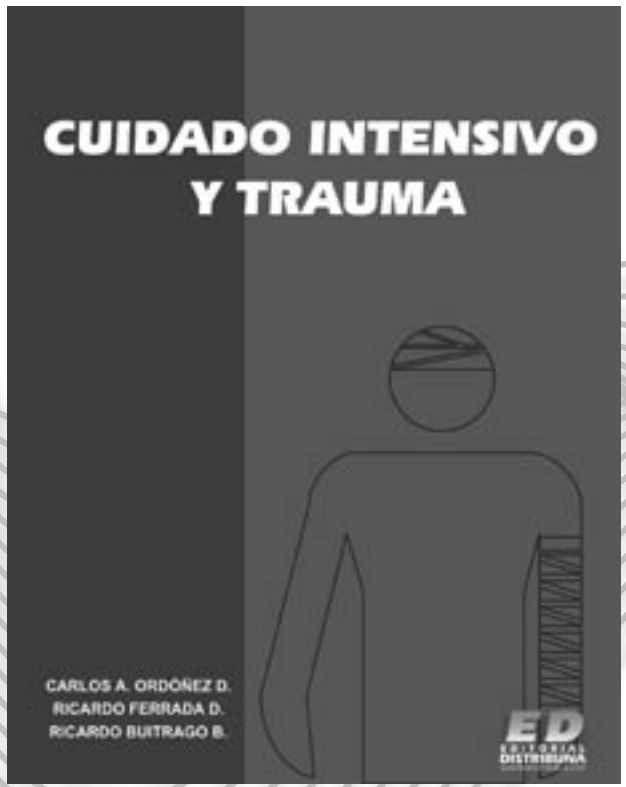
90. Wall M. Trauma to cardiac valves. Curr opin Cardiol 2002; 17: 188-192.

91. Ivatury R, Nallathambi M, Stahl W, Rohman M. Penetrating cardiac trauma. Quantifying the severity of anatomic and physiologic injury. Ann Surg 1987; 205: 61-66.

92. Velmahos G, Degiannis E, Souter I, Saadia R. Penetrating trauma to the heart: A relatively innocent injury. Surgery 1994; 115: 694-697.

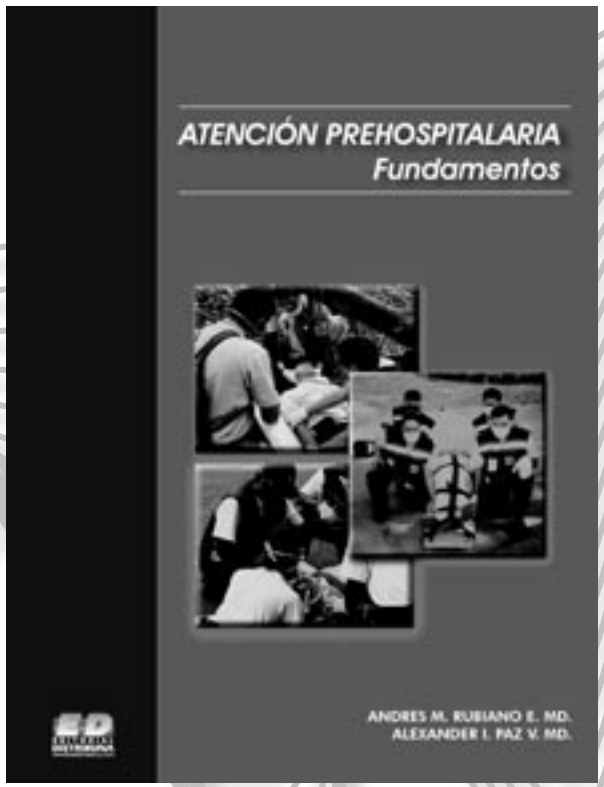
93. Asensio J, Murray J, Demetriades D, et al. Penetrating cardiac injuries: A prospective study of variables predicting outcomes. J Am Coll Surg 1998; 186: 24-34.

PRIMERA REIMPRESIÓN



ORDOÑEZ
CUIDADO INTENSIVO Y TRAUMA

Autor:	Carlos A Ordóñez D MD, Ricardo Ferrada D. MD, Ricardo Buitrago B. MD
Páginas:	880
Edición:	2002
ISBN:	958-332679-8
Pasta:	Dura
Imágenes:	134 Color 183 B/N
Formato:	28.5x22.5 cm
Peso:	6 Libras



RUBIANO
ATENCIÓN
PREHOSPITALARIA FUNDAMENTOS

Autor:	Andrés M. Rubiano E. MD Alexander I. Paz V. MD.
Páginas:	1010
Edición:	2004
ISBN:	958-336354-5
Pasta:	Dura
Formato:	21.5x27.5 cm
Peso:	5 Libras

Solicitelo en la Librería Médica Distribuna
Bogota - Colombia: Autopista Norte No. 123 - 93
Tels: (57-1) 2158335 - 6202294 - 2132379
Fax: (57-1) 2132379
Buzón telefónico (57-1) 2161588
E-mail: gerencia@libreriamedica.com
servicioalcliente@libreriamedica.com
Cualquier inquietud o duda con gusto la atenderemos de inmediato.

ED
EDITORIAL
DISTRIBUNA
www.libreriamedica.com

www.libreriamedica.com