Effectiveness of Peritoneal Lavage in Blunt Abdominal Trauma

LCDR STEVE PARVIN, MC USN, LCDR DAVID E. SMITH, MC USN,
CDR W. MICHAEL ASHER, MC USN, CDR RICHARD W. VIRGILIO, MC USN

To analyze the effectiveness of peritoneal lavage and to define its limitations in the evaluation of patients who have sustained blunt abdominal trauma, a prospective study of 500 such patients was undertaken by the Trauma Service at the Naval Hospital, San Diego. Utilizing a qualitative colorometric method to evaluate the degree of hemoperitoneum, patients could rapidly be divided into three clinical groups: strongly positive, weakly positive, and negative. Using this method, patients with a strongly positive peritoneal lavage had a 94% incidence of significant intra-abdominal injuries. In 333 patients with a negative lavage, there was no documented incidence of significant intra-abdominal injuries. In the weakly positive lavage group, only 9 patients out of 99 subsequently proved to have significant intra-abdominal injuries. Visceral angiography and abdominal echography were utilized in this group of patients to identify those with significant intra-abdominal injuries. By utilizing this approach, there were only eight unnecessary celiotomies in the total group of 500 patients. It is concluded, therefore, that peritoneal lavage is a safe, rapid, and effective means of evaluating patients who have sustained blunt abdominal trauma.

From the Trauma Research Unit and Department of Radiology, Naval Regional Medical Center, San Diego, California

WITH the increased incidence of highway accidents the surgeon is confronted more often with the responsibility of making a rapid, accurate assessment of intraperitoneal injuries in the patient who has sustained blunt injury to his abdomen. The rapidity and accuracy of this initial assessment becomes of utmost importance, since the associated morbidity and mortality is directly related both to the magnitude of the injury and to delays in instituting appropriate therapy. Physical examination in this group of patients is often misleading and routine laboratory work and x-rays are seldom helpful. Surgeons in several large institutions[1,4,8,10,12,13,15] have, therefore, begun to utilize peritoneal lavage to aid them in deciding whether immediate celiotomy is necessary or whether the treatment of associated injuries can be safely undertaken.

To analyze not only the effectiveness of this procedure but also to define its limitations in the evaluation of the patient who has sustained blunt abdominal injury, a prospective study of 500 such patients was undertaken by the Trauma Service at the Naval Hospital San Diego.

Materials and Methods

From April, 1972 through January, 1974, 500 consecutive patients with blunt abdominal trauma were evaluated by the Trauma Service and underwent peritoneal lavage. This included all patients who had sustained sufficient force to have caused intra-abdominal injury regardless of abdominal findings. The only contraindications to lavage were: 1)multiple previous abdominal operations; 2) a pregnant patient; or 3) an unstable patient requiring immediate surgery.

All patients were classified into four clinical groups by the senior surgical resident on the basis of physical findings: 1) surgical, 2) equivocal, 3) non-surgical, and 4) unconscious. After initial resuscitation, they underwent peritoneal lavage using the technique described by Root[13] and modified by Perry.[11] Adult patients were lavaged with 1

Submitted for publication July 22, 1974.

The opinions or assertions contained herein are those of the authors and are not to be construed as official or reflecting the views of the Navy Department.

Reprint requests: Cdr. Richard W. Virgilio, Trauma Research Unit, Naval Regional Medical Center, Park Boulevard, San Diego, California 92134.

TABLE 1. *Correlation of Peritoneal Lavage Results and Initial Physical Examinations With the Incidence of Significant Intraperitoneal Injuries*

Clinical Evaluation	Lavage Results: Strongly Positive No. Patient	Strongly Positive No. Injuries	Strongly Positive %	Weakly Positive No. Patient	Weakly Positive No. Injuries	Weakly Positive %	Negative No. Patient	Negative No. Injuries	Negative %	Total Patients	Total Injuries	Total %
Surgical	39	35	90	6	2	33	17	0	0	62	37	60
Equivocal	12	12	100	43	4	9	101	0	0	156	16	10
Non-surgical	12	12	100	43	3	7	198	0	0	253	15	6
Unconscious	5	5	100	7	0	0	17	0	0	29	5	17
Total	68	64	94	99	9	9	333	0	0	500	73	15

Liter of normal saline while 20 cc/kg saline was used in children. When the infusion was completed, the empty bottle was placed on the floor and allowed to drain by gravity. The fluid was interpreted by the qualitative colorimetric method originally described by Olsen.[10] Using this technique, patients were divided rapidly into three groups: negative, weakly positive, and strongly positive.

Patients with a strongly positive lavage underwent immediate celiotomy. Those with a negative lavage were admitted for treatment of associated injuries or for observation for 24 hours. Those with a weakly positive lavage underwent further diagnostic evaluation to determine if there was a significant intra-abdominal injury. This included abdominal echography in all patients and visceral arteriography in patients with positive echograms. All patients with a positive arteriogram underwent celiotomy. Aliquots of lavage fluid were sent to the laboratory for WBC count, amylase, gram stain, and culture and sensitivity.

Results

Table 1 summarizes the data. In 500 lavages there were 68 strongly positive, 99 weakly positive, and 333 negative lavages. Of the strongly positive group, 64 had a significant injury at celiotomy for a 94% accuracy. In the weakly positive group, only 9 of 99 had a significant injury (9%). Considering all patients with hemoperitoneum only 73 of 167 (44%) had a significant injury. In the negative group of 333 there were no significant injuries.

TABLE 2. *Significant Intra-abdominal Injuries*

	Strongly Positive Lavage Group	Weakly Positive Lavage Group	Total
Spleen	45	4	49
Liver	15	2	17
Kidney	3	3	6
Mesentery	4	1	5
Pancreas	3	1	4
Intestine	3	0	3
Bladder	2	0	2
Diaphragm	0	1	1
Vascular (Venous)	3	1	4
Omentum	1	0	1
Other	1	0	1
	80	13	93

The inaccuracy of the initial physical examination is indicated in Table 1. Of 62 patients that were considered to have a surgical abdomen on initial evaluation and who would have undergone a celiotomy only 37 (60%) had a significant intra-abdominal injury. Therefore, 25 patients (40%) were spared an unnecessary celiotomy. Of the patients felt to have a non-surgical abdomen on initial evaluation, 15 of 253 (6%) were found to have a significant injury. In the equivocal group only 16 of 156 (10%) were found to have a significant intra-abdominal injury. Five of 29 (17%) of the unconscious patients had significant intra-abdominal pathology. The injuries encountered are listed in Table 2 and as expected solid viscus injury (spleen, liver) was the most common. In the weakly positive group of 99 patients there were 41 normal, 20 abnormal and 2 unsatisfactory echograms. Of the 20 abnormal echograms significant injuries were documented in only three cases. There were no false negative echograms. Of 42 visceral arteriograms in this group, there were 33 normal, 8 abnormal, and one unsatisfactory study. All 8 patients with an abnormal arteriogram underwent celiotomy and five had a significant intra-abdominal injury.

In the 500 patients there were 81 celiotomies. In 8 of these no significant intra-abdominal injury was demonstrated.

TABLE 3. *Summary of Operative Indications and Injuries in the Eight Negative Celiotomies*

Lavage Group	Patient No.	Operative Indication	Operative Findings
Strongly positive	1	Lavage findings	Omental tear
	2		Retroperitoneal hematoma
	3		Minor liver lacerations
	4		None*
Weakly positive	5	Positive splenic arteriogram	None
	6	Positive splenic arteriogram	Minor liver laceration
	7	Positive hepatic arteriogram	Retroperitoneal hematoma
	8	Change in clinical course	None

*Incorrect lavage technique.

TABLE 4. *Lavage WBC Count and Amylase Values*

Lavage Result	*Lavage WBC*		*Lavage Amylase*	
	<500/mm³	>500/mm³	<100A.U.%	>100A.U.%
Strongly Positive	5 (5)	12 (12)	20 (19)	3 (3)
Weakly Positive	43 (1)	11 (0)	57 (1)	3 (1)
Negative	175 (1)*	18 (1)*	196 (0)	9 (0)
Total	223 (7)	41 (13)	273 (20)	15 (4)

( ) Denotes the number of patients with a significant injury.
* Renal injury without intraperitoneal trauma.

Four were in the strongly positive group and four were in the weakly positive group (Table 3). Three of the four strongly positive lavages had an insignificant injury (minor liver laceration, omental tear, retroperitoneal hematoma) and one lavage was performed incorrectly. In the weakly positive group, three of the four unnecessary operations were performed because of false positive angiograms. The fourth case was operated on early in the study in spite of a negative arteriogram because of significant physical findings.

There were 264 lavage fluid WBC count and 288 lavage amylase values available for analysis (Table 4). In the group of 223 patients with less than 500 WBC/mm³ in the lavage fluid, there were six significant intra-peritoneal injuries and one retroperitoneal injury. The six intraperitoneal injuries all had positive lavages. The retroperitoneal injury was a patient with a negative lavage who had hematuria and a positive IVP for a renal injury. There were 41 patients with a lavage WBC count greater than 500/mm³ and only 13 of these had a significant injury. Twelve of these were intraperitoneal injuries and all had strongly positive lavages. The other patient had a renal injury with a negative lavage. Thus, 17 of 18 patients (94%) with an elevated lavage WBC count in the negative lavage group had no intra-abdominal injury. Of the 273 patients with a lavage amylase less than 100 AU%, 20 had a significant injury. All 20 of these were operated on because of strongly or weakly positive lavage. Only four of 15 patients with a lavage amylase greater than 100 AU% had a significant injury and all four had concomitant hemoperitoneum. Nine patients with negative lavages and elevated lavage fluid amylases proved to have no intra-abdominal injury.

In 500 peritoneal lavages there were no major complications. There was a 6% incidence of minor complications including wound separation and wound hematoma.

Discussion

Two of the strongest criticisms of the use of peritoneal lavage as a diagnostic tool in blunt abdominal trauma center around its potential complications and also its extreme sensitivity in diagnosing clinically insignificant hemoperitoneum. Major complications that have been reported with the use of peritoneal lavage have been visceral perforation and hemorrhage secondary to lacerations of major vessels.[15] The incidence of these complications can be minimized by excluding patients with a history of multiple abdominal surgical procedures, the use of countertraction after direct visualization of the linea alba, and insuring that the bladder is emptied. Adherance to these criteria has eliminated any major complications in our 500 patients. Our morbidity rate of 6% consisted only of local wound problems such as hematoma and separation. We feel that the following are absolute contraindications to peritoneal lavage: 1) history of multiple abdominal surgical procedures; 2) pregnancy; and 3) the presence of a full bladder. If a patient has had lower abdominal surgery or a fractured pelvis, the peritoneal lavage can be safely done through an upper midline incision.

It is true that peritoneal lavage is extremely sensitive in determining the presence of blood within the peritoneal cavity. This is graphically demonstrated by the fact that as little as eight drops of blood in a liter of saline will cause a pink discoloration to appear. Indeed, if we had used the presence of any degree of hemoperitoneum alone as an indication for celiotomy our incidence of negative celiotomies would have been 66% rather than our true incidence of 5%. As a result of this oversensitivity of the peritoneal lavage technique, several methods have been recommended to quantitate the degree of hemoperitoneum and to correlate this with clinical significance.[4,10,11,12,15] These include measuring the hematocrit, red blood cell count, and finally the qualitative colorimetric method first described by Olsen.[10] This latter technique has the advantage of allowing the physician at the bedside to quickly place the patient into one of three groups: 1) strongly positive; 2) weakly positive; and 3) negative. We adopted this latter method because of its bedside applicability and because of the fact that in Olsen's series there was a good clinical correlation. Ninety-eight per cent of the patients in his strongly positive group had significant intra-abdominal injuries, while only 32% of the patients in his weakly positive group had significant injuries. When we applied these same criteria for division of our patients, we had a 94% incidence of significant injuries in the strongly positive group and only a 9% incidence in the weakly positive group. We feel that this discrepancy in the weakly positive group is due to the larger percentage (57/99 vs 3/25) of trace lavage in our series. Actually our incidence of significant injuries in the weakly positive group would have been 21% if we had excluded the trace lavage. This group probably represents contamination from abdominal wall bleeding. In both series, the presence of an absolute negative lavage ruled out significant intra-abdominal injuries in 100% of the cases. From this data, it is apparent that the weakly positive lavage group requires further evaluation as less than one third will have significant intra-abdominal injuries. It is

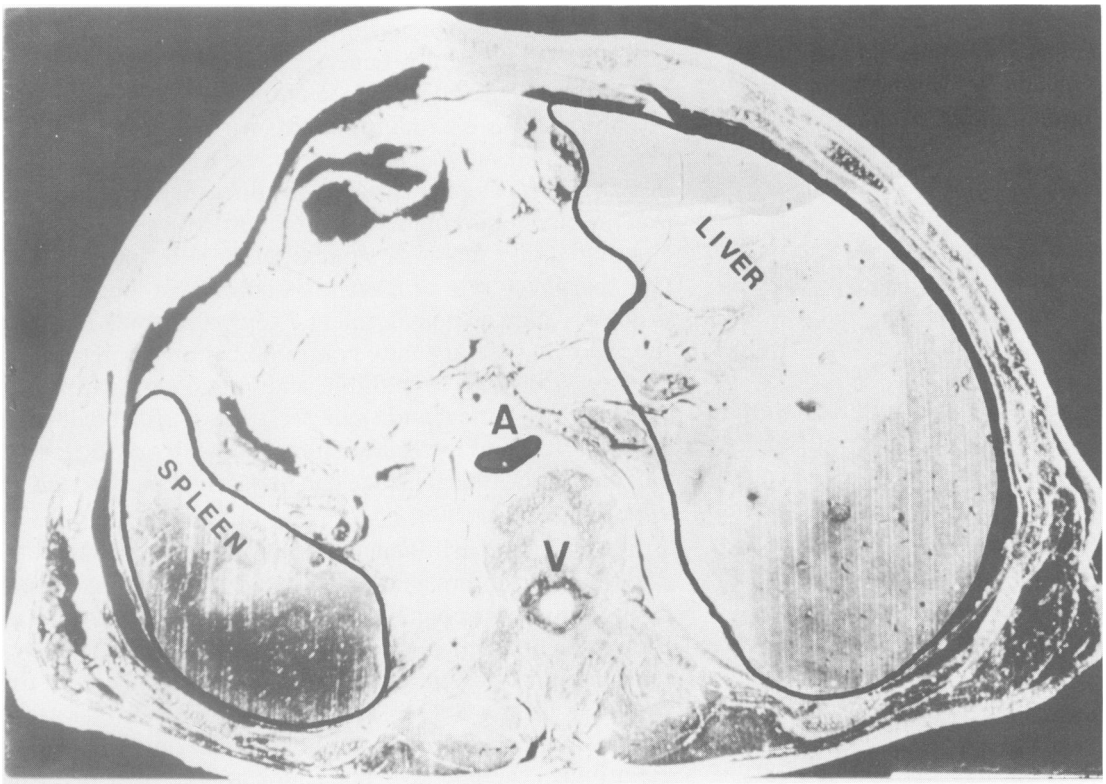

FIG. 1. Cross section of a supine cadaver. Note the medial border of the spleen is smooth and the anterior edge does not extend past the level of the aorta (A). (V) represents the vertebral body.

within this group that the use of echography and abdominal angiography proved to be helpful.

Echography is a rapid, non-invasive technique utilizing ultrasound to define the configuration of both intra-abdominal and retroperitoneal structures.[3] Its use in the area of blunt abdominal trauma is for the most part limited to the diagnosis of splenic injury. Criteria for ruptured spleen by echography center around demonstration of enlargment and irregularity in its contour (Figs. 1-3). In our series, the percentage of false positive echograms (85%) precluded the use of this technique as a criterion for exploratory celiotomy. However, we had no false negative

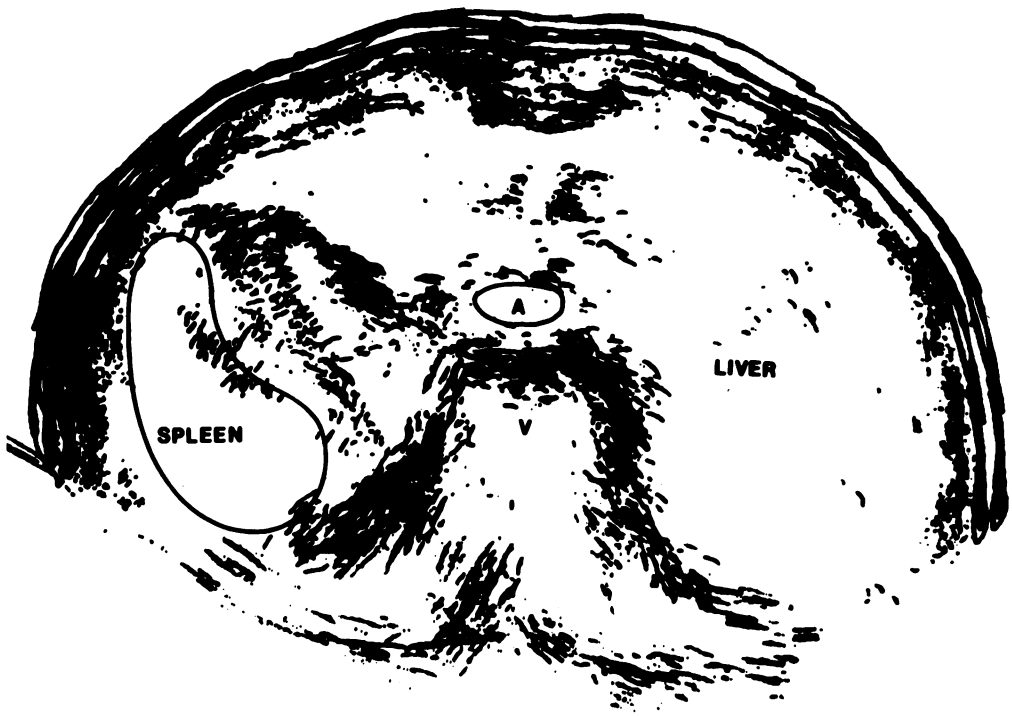

FIG. 2. Normal spleen by echography. Note the smooth medial contour and that the anterior edge is parallel with the aorta (A). (V) represents the vertebral body.

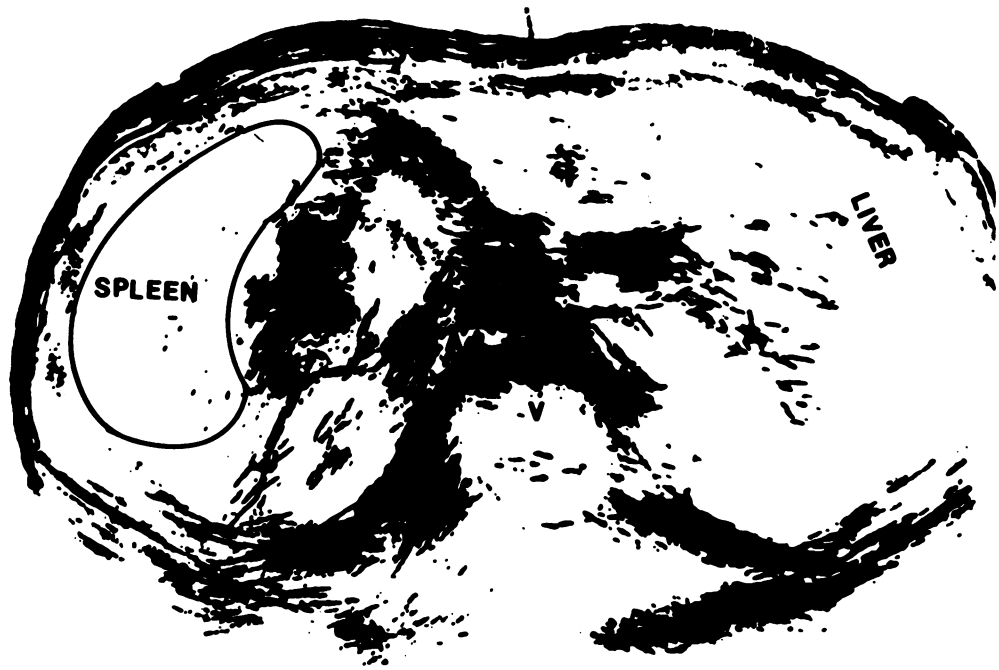

FIG. 3. Ruptured spleen by echography. Note the marked enlargement of the spleen with the anterior edge extending almost to the anterior abdominal wall. (V) represents the vertebral body.

echograms, therefore, the technique may be useful as a rapid non-invasive maneuver in patients with a weakly positive lavage. If the echogram is positive then it is imperative that the patient undergo visceral arteriography. We use flush abdominal aortograms followed by selective celiac studies. By using this technique, hepatic, renal and intestional injuries can be documented in addition to splenic injuries. The criteria commonly used for the diagnosis of splenic injury are:[5,16] 1) puddling of the dye; 2) stretched displaced vessels; 3) avascular areas; 4) early venous filling; and 5) pseudo-aneurysms. Figures 4 and 5 demonstrate several of these abnormalities. By utilizing the combination of echography and arteriography in the group of 99 patients with a weakly positive lavage only 12 of these patients underwent celiotomy. Within this group of 12 patients there were 9 significant intra-abdominal injuries and only 3 negative celiotomies. These 3 patients represented false positive angiograms. Thus, by taking the more aggressive diagnostic approach and the more conservative clinical approach, 87 patients of the 99 with a weakly positive lavage were spared an unnecessary celiotomy. The attending physicians were thus able to rapidly proceed with the care of associated injuries without the fear of overlooking significant intra-abdominal pathology.

It has been suggested that greater than 100 amylase units per cc of clear peritoneal lavage fluid is diagnostic of pancreatic or small bowel injuries in patients sustaining blunt abdominal trauma.[11,12,15] In our series there were nine instances in which the lavage amylase was greater than 100 amylase units % in patients with a negative lavage. None of these patients had a significant intra-peritoneal injury. Of the six patients with hemoperitoneum and an elevated la-

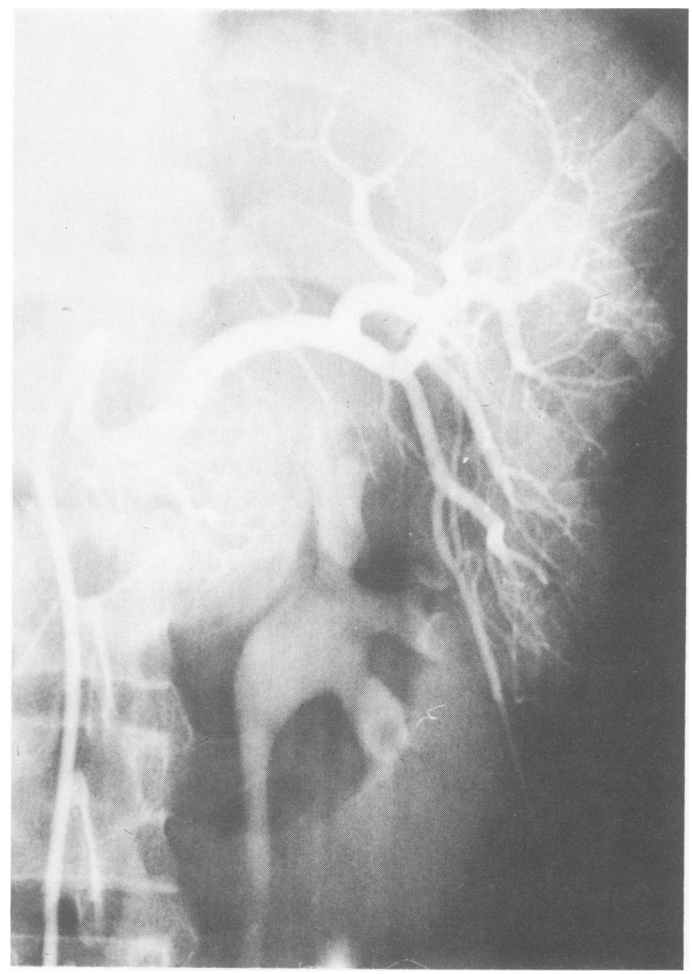

FIG. 4. Ruptured spleen by arteriography (arterial phase). Note stretching of the splenic arteries in the upper pole.

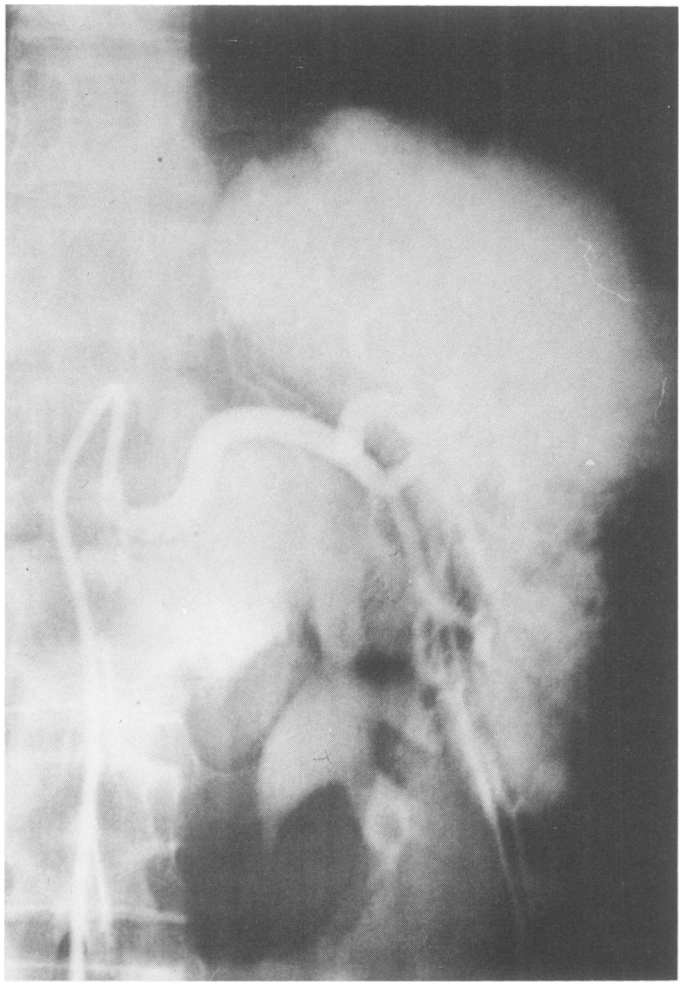

FIG. 5. Ruptured spleen by arteriography (venous phase). Note the large avascular area in the lower pole.

vage amylase, four had significant injuries. Three of these were in the strongly positive group and would have been operated on this basis alone. The fourth patient with a significant injury was in the weakly positive group and had a renal injury requiring nephrectomy. This injury was diagnosed by visceral arteriogram and IVP. We, therefore, feel that an elevated lavage fluid amylase in a clear aspirate is not an indication for celiotomy. It has been recently demonstrated that the level of serum amylase was also a poor predictor of the presence or absence of significant injuries.[9] However, we feel that an elevated lavage amylase and a progressively increasing serum amylase coupled with persistant abdominal findings should be an indication for exploratory celiotomy.

The presence of over 500 white blood cells within the peritoneal lavage fluid has been used as an indication for celiotomy.[11,12,15] In our 18 patients with a clear lavage and an associated white count greater than 500/mm^3 only one had a significant injury. This patient had a lacerated kidney that was diagnosed by an IVP performed for gross hematuria. If an elevated lavage fluid white count had been used as an indication for exploration, 17 patients would have undergone unnecessary celiotomy. We thus feel that the presence of white cells within clear peritoneal lavage fluid is not in itself an indication for celiotomy.

This study re-emphasizes the inaccuracy of the initial physical examination in patients with blunt abdominal trauma. Forty per cent of the patients felt to have a surgical abdomen had no intra-abdominal injury. We feel this high incidence of false positive exams is caused by abdominal wall contusions and associated injuries of the chest, spine, and pelvis which produce muscular spasm indistinguishable from the guarding associated with true intraperitoneal injury. It is also evident that there are fewer false negative exams, with the overall incidence in our series being 6%. The negative initial physical examination with significant intra-abdominal injury may be ascribed to the frequency of solid organ injury in blunt abdominal trauma. The hemoperitoneum accompanying this type of injury produces much less peritoneal irritation than intestinal contents. We had several patients with large amounts of blood in their peritoneal cavity with no abnormal physical findings. The high degree of accuracy with peritoneal lavage as contrasted to the relative inaccuracy of the physical examination has led to a marked decrease in overall morbidity in our patients. It is apparent that 40% of the patients with false positive physical examinations were spared an unnecessary laparotomy and there was no delay in managing their associated injuries. Six per cent of patients with initial false negative exams as well as 10% of patients in the equivocal group had a minimal delay in exploration.

The morbidity and mortality of negative laparotomy is frequently underestimated while the complications associated with a missed injury are well-known.[2] A recent report on penetrating trauma had a corrected operative mortality for a negative celiotomy of 1.6% with a morbidity rate of 19–23%.[6] Maynard and Oropeza[7] reported five deaths in 79 negative celiotomies (6.3%) for penetrating injuries. Similar statistics are unavailable for blunt abdominal trauma. However, one would postulate because of the frequently associated multiple injuries that there would be an increased morbidity and mortality.

Although peritoneal lavage is highly accurate in diagnosing intraperitoneal injuries, it is not as accurate with retroperitoneal injuries. Occasionally these injuries may be detected by peritoneal lavage because of the diapedesis of red cells through the posterior parietal peritoneum. There were three major isolated renal injuries in our series without significant intraperitoneal damage which produced a weakly positive lavage. However, this should not be relied on and if a retroperitoneal injury is suspected, an intravenous pyelogram, renal arteriogram, or gastrografin duodenogram should be performed.

To manage blunt abdominal trauma rapidly and efficiently, we recommend the following protocol. In the

emergency room a lavage is performed and if strongly positive, (red and opaque or print cannot be read through the tubing), the patient undergoes immediate celiotomy. If the lavage is negative and there are no associated injuries, the patient is observed for 24 hours. If the lavage is weakly positive, (pink and clear or print can be read through the tubing), the patient undergoes echography and arteriography, if stable. If the arteriogram is positive the patient undergoes celiotomy and if negative the patient is observed 48 hours. Thus, our indications for celiotomy in blunt abdominal trauma are: 1) a strongly positive lavage; 2) a weakly positive lavage with positive arteriogram; and 3) an unstable patient.

References

1. Cafee, H. H. and Benfield, J. R.: Is Peritoneal Lavage for the Diagnosis of Hemoperitoneum Safe? Arch. Surg., 103:4, 1971.
2. DiVincenti, F. C., Rives, J. D., Laborde, E. J., *et al.*: Blunt Abdominal Trauma. J. Trauma, 8:1004, 1968.
3. Freimanis, A. K. and Asher, W. M.: Development of Diagnostic Criteria in the Echographic Study of Abdominal Lesions. Am. J. Roentgenol., 108:747, 1970.
4. Jahadi, M. R.: Diagnostic Peritoneal Lavage. J. Trauma, 12:936, 1972.
5. Love, L., Greenfield, G. B., Braun, *et al.*: Arteriography of Splenic Trauma. Radiology, 91:96, 1968.
6. Lowe, R. J., Boyd, D. R., Folk, F. A. and Baker, R. J.: The Negative Laparotomy for Abdominal Trauma. J. Trauma, 12:853, 1972.
7. Maynard, A. L. and Oropeza, G.: Mandatory Operations for Penetrating Wounds of the Abdomen. Am. J. Surg., 115:307, 1968.
8. Olsen, W. R. and Hildreth, D. H.: Abdominal Paracentesis and Peritoneal Lavage in Blunt Abdominal Trauma. J. Trauma, 11:824, 1971.
9. Olsen, W. R.: The Serum Amylase in Blunt Abdominal Trauma. J. Trauma, 13:200, 1973.
10. Olsen, W. R., Redman, H. C. and Hildreth, D. H.: Quantitative Peritoneal Lavage in Blunt Abdominal Trauma. Arch. Surg., 104:536, 1972.
11. Perry, J. F., Jr.: Blunt and Penetrating Abdominal Injuries. Curr. Probl. Surg., 1970, p 5.
12. Perry, J. F., Jr. and Strate, R. G.: Diagnostic Peritoneal Lavage in Blunt Abdominal Trauma: Indications and Results. Surgery, 71:898, 1972.
13. Root, H. D., Hauser, C. W., McKinley, *et al.*: Diagnostic Peritoneal Lavage: Surgery, 57:633, 1965.
14. Root, H. D., Keizer, P. J. and Perry, J. F.: The Clinical and Experimental Aspects of Peritoneal Response to Injury. Arch. Surg., 95:531, 1967.
15. Thal, E. R. and Shires, G. T.: Peritoneal Lavage in Blunt Abdominal Trauma. Am. J. Surg., 125:64, 1973.
16. Thompson, D. P., Schultz, E. H. and Benfield, J. R.: Celiac Angiography in the Management of Splenic Trauma. Arch. Surg., 99:494, 1969.