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Stab Wounds of the Anterior Abdomen

Analysis of a Management Plan Using Local Wound Exploration and Quantitative Peritoneal Lavage

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A management plan for stab wounds to the anterior abdomen incorporating local wound exploration and quantitative peritoneal lavage was applied to 572 patients. One hundred eighty-five of these patients presented with shock, peritonitis, or evisceration and underwent immediate exploratory laparotomy with the finding of an intraperitoneal organ injury in 183 (99%). The remaining 387 patients with a negative physical examination underwent exploration of the stab wound to determine fascial penetration. Wound exploration was negative in 151 of these patients and they were discharged from the emergency room. Two hundred thirty-six additional patients had penetration of the fascia and underwent peritoneal lavage. Ninety-two per cent of patients with lavage counts greater than 50,000 had an intraperitoneal organ injury. No patients with lavage counts less than 1,000 red cells had an organ injury. Forty-three per cent of patients in the intermediate group (1,000–50,000 RBCs/mm^3) had an organ injury and 59% included penetration of a hollow viscus. An approach incorporating local wound exploration and quantitative peritoneal lavage followed by exploratory laparotomy for red blood cell counts greater than 1,000 should result in less than 10% negative laparotomies and no missed injuries.

THE TRADITIONAL APPROACH to the management of patients with stab wounds to the lower chest and anterior abdomen has been exploratory laparotomy. However, the use of mandatory exploratory laparotomy for all such patients results in a negative exploration rate of 31–63%.[1,2] There is a small but significant morbidity and mortality consequent to the anesthesia and nonproductive celiotomy in this group of patients.[3–5] Nonproductive explorations should be minimized, but not at the expense of increased morbidity and mortality due to a delay in appropriate operative intervention. To achieve this goal, a variety of programs for selective management of abdominal stab wounds have been proposed. These include exploratory laparotomy based on: (1) physical examination only, (2) sinogram, (3) local wound exploration, and (4) peritoneal lavage.[6–9] The optimal algorithm for determining the need for laparotomy, however, has not been established. In the present study, we prospectively evaluated the established modalities of physical examination, local exploration, and peritoneal lavage in an attempt to develop a management plan that would maximize diagnostic accuracy and minimize nonproductive laparotomies without increasing the morbidity and mortality related to delays in appropriate operative intervention.

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Materials and Methods

From January 1, 1978 to December 31, 1982, 572 patients with stab wounds to the anterior abdomen pre-

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TABLE 1. *Results According to Groupings*

	No. Pts.	Physical Exam	Wound Expl.	Lavage Results (RBC/mm^3)	Mgt.	Outcome	
						Organ Inj.	No Organ Inj.
Group A	185	Shock, peritonitis, or evisceration	Not done	Not done	Expl. lap.	183	2
Group B	151	"Negative"	"neg"	Not done	Home	0	151 (83% follow-up)
Group C	236	"Negative"	"pos"	<1,000	Expl. lap.*	0	67
				1,000–50,000	Expl. lap.	35	47
				50,000–100,000	Expl. lap.	12	3
				>100,000	Expl. lap.	68	4

* The initial 27 patients underwent exploratory laparotomy which was nonproductive. The remaining 40 patients were observed for 24 hours.

sented to Harborview Medical Center. Patients with associated extra-abdominal injuries were excluded from the study. The abdomen was defined as the area bounded by the costal margin superiorly, anterior axillary lines laterally, and groin creases inferiorly.

The following therapeutic plan was carried out: (1) Patients who had a "positive" physical examination underwent immediate exploratory laparotomy (after the initiation of fluid resuscitation and administration of prophylactic antibiotics). A physical examination was defined as "positive" if there was evidence of shock, peritonitis, or evisceration. (2) Patients who were hemodynamically stable and had no signs of peritonitis underwent careful wound exploration by the responsible surgical team. (3) If the depths of the wound could be seen at local exploration and there was no evidence of fascial penetration, the wound was irrigated and drained. The patient was then discharged from the emergency department. (4) If the depths of the wound could not be seen *or* the anterior abdominal wall fascia was penetrated, peritoneal lavage was performed. These patients then underwent exploratory laparotomy.

Local wound exploration was performed after sterile preparation of the skin, by infiltrating with a local anesthetic and surgically extending the wound so that it could be inspected under direct vision. Peritoneal lavage was performed through an infraumbilical midline incision. The catheter was inserted into the peritoneum under direct vision. Lactated Ringer's, at 15 cc/kg, was infused intraperitoneally, recovered and analyzed for red cell count/mm^3, white cell count/mm^3, amylase, and bilirubin. An aliquot was submitted for Gram's stain and culture.

Each patient was entered into the registry of the Peritoneal Lavage Study. The initial physical findings, characteristics of the stab wound, description of the local wound exploration, results of the peritoneal lavage, findings at the time of laparotomy, and immediate outcome were entered into the flow chart of the registry. Particular note was made of the occurrence of hollow viscus penetration.

All patients were followed for a minimum of 30 days after discharge by one of the investigators (MRO).

The data was expressed and analyzed according to groups with respect to the indication for operation and presence of significant intra-abdominal organ injury. A significant injury was defined as one requiring hemostasis, repair, or drainage.

The design and content of the study was reviewed and approved by the Human Subjects Review Committee.

Results

Five hundred seventy-two patients managed according to the protocol of physical examination, local wound exploration, and peritoneal lavage were divided into three groups for purposes of analysis (Table 1).

Group A

Group A consists of 185 patients who presented with a "positive" physical examination. Wound exploration and peritoneal lavage were not performed. All of these patients underwent exploratory laparotomy. Ninety-nine per cent of these patients were transported by a single prehospital care system. Two were referred from another hospital.

One hundred eighty-three (99%) of the patients in Group A were found to have a significant intra-abdominal injury. Ninety-one (49%) patients had more than one injury and 22 (12%) had a major vascular injury. Of the 92 single injuries, 81 involved solid organs (liver, spleen, pancreas, mesentery, kidney, or retroperitoneum).

There were two negative laparotomies. One patient (who presented profoundly hypotensive) had a stab wound through the superior epigastic artery but no intra-abdominal injury. A second patient, who was felt to have

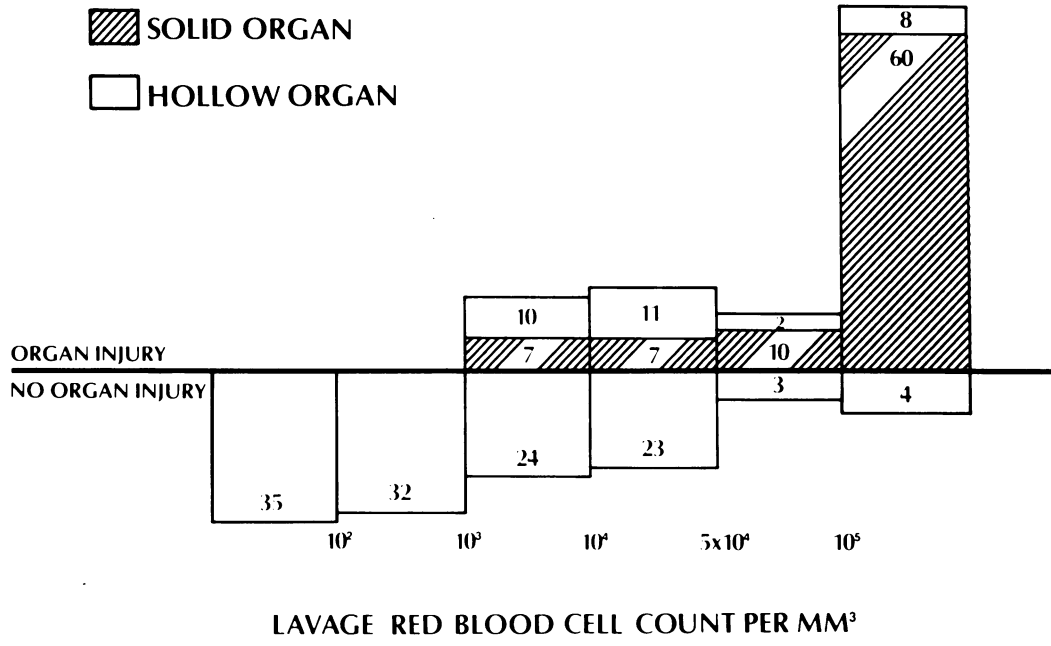

FIG. 1. Correlation of lavage red blood cell count with presence of organ injury.

peritonitis, had a negative laparotomy. (Two additional patients with large slash wounds underwent exploratory laparotomy in conjunction with debridement and hemostatic control of the large abdominal wall defects. They were excluded from the study.)

The remaining 387 patients had a "negative" physical examination. They *all* underwent *local* wound exploration. They are divided into Groups B and C.

Group B

Group B consists of 151 patients with a "negative" physical examination whose stab wounds were explored under local anesthesia and were not found to penetrate the fascia. Following debridement and appropriate wound management, these patients were discharged from the emergency room.

No patient in this group underwent exploratory laparotomy, either at the time of presentation or in the initial follow-up period. One patient returned with bleeding from the wound requiring ligation of a muscle bleeder. One hundred twenty-five (83%) patients were successfully followed for one month. None of these patients required subsequent hospitalization. Four developed minor wound infections and were treated as outpatients.

Group C

Group C consists of 236 patients who had a negative physical examination but a *positive* local wound exploration. Their only indication of intra-abdominal injury was penetration of the fascia by the knife wound. All of these patients underwent peritoneal lavage followed by exploratory laparotomy (see exceptions under subgroup C_4). They were divided into subgroups based on quantitative analysis of the results (Table 1).

Subgroup C_1 consists of 72 patients whose peritoneal lavage fluid contained over 100,000 RBCs/mm^3 (Fig. 1). Sixty-eight (94%) had a positive exploratory laparotomy, 60 had a solid organ injury, and six patients (8%) had hollow viscus injuries (including two colon injuries). Two patients had combined solid and hollow organ injuries. There were four negative laparotomies—the hemoperitoneum was attributed to bleeding from the stab wound site into the abdominal cavity.

Subgroup C_2 consists of 15 patients whose peritoneal lavage fluid contained between 50,000 and 100,000 RBCs/mm^3 (Fig. 1). Twelve had a positive laparotomy, 10 of the 12 (83%) had a solid organ injury, and three had no evidence of visceral injury at the time of exploration.

Subgroup C_3 consists of 82 patients with between 1,000 and 50,000 RBCs/mm^3 in the lavage fluid. Forty-seven (57%) had no evidence of visceral injury at the time of exploration. Thirty-five patients had a positive laparotomy. Twenty-one of these 35 patients had a hollow organ injury—seven of these penetrated the colon (Table 2). One patient (JG) with 12,500 RBCs initially refused laparotomy. He subsequently developed abdominal tenderness and was found to have localized peritonitis secondary to a 1-cm perforation of the jejunum.

Subgroup C_4 consists of 67 patients with less than 1,000 RBCs/mm^3 (Fig. 1). The first 27 of these patients un-

TABLE 2. *Results of Peritoneal Lavage in the 21 Hollow Viscus Injuries (<50,000 RBCs/mm³)*

Patient	Injury	RBCs	WBCs	Bilirubin	Amylase	Gram's stain
1. A.G.	Stomach	3,260	0	0	0	Neg.
2. C.G.	Desc. colon	2,000	6	0	0.8	? Gm neg. rod.
3. J.S.	Stomach	15,600	22	0	0	Neg.
4. H.M.	Jejunum	3,760	55	0	1.9	Neg.
5. T.M.	Stomach, pancreas, liver, gall gladder, IVC.	29,200	100	0	2.0	Neg.
6. M.L.	Jejunum	23,425	225	0.1	0.8	Neg.
7. S.S.	Trans. colon	3,550	10	0	0	? Gm neg. rod.
8. J.G.	Jejunum	12,500	28	0.1	0.4	Neg.
9. K.H.	Stomach	18,800	233	0.1	0.1	Neg.
10. T.L.	Stomach	1,290	2	0	0	Neg.
11. L.T.	Jejunum	1,400	0	1.5	0	Neg.
12. A.L.	Desc. colon	24,100	0	0	0.4	Neg.
13. A.W.	Stomach	3,925	27	0	0	Neg.
14. M.C.	Jejunum	20,600	34	0.2	0.1	Neg.
15. B.C.	Stomach	2,620	220	0	0.2	Neg.
16. J.M.	Trans. colon	34,720	50	0	0	Neg.
17. T.M.	Ileum	8,150	70	0	1.7	Neg.
18. R.M.	Trans. colon	11,200	0	0.1	0	Neg.
19. R.L.	Jejunum	9,400	0	0.2	2.4	Neg.
20. F.G.	Ascend. colon	15,670	10	0	0.2	Neg.
21. M.T.	Desc. colon	19,400	12	0	0.4	Neg.

derwent an exploratory laparotomy, *which was negative in all.* The subsequent 40 patients did not undergo exploratory laparotomy but instead were admitted for 24 hours of observation. All 40 were followed for a minimum of 30 days. None of these patients developed signs of intra-abdominal injury.

The results of the quantitative peritoneal lavage in all Group C patients was compared to the presence of hollow viscus injury (Fig. 1).

Discussion

Diagnostic peritoneal lavage is an extension of the previous technique of needle aspiration of the peritoneal cavity. In 1965, Root and coworkers published their experience with diagnostic peritoneal lavage in 28 patients with *blunt* abdominal trauma.[10] The diagnostic accuracy with lavage in that first report was 100% with one complication. Since 1965, multiple reports from several investigators have confirmed the accuracy of diagnostic peritoneal lavage for patients who have sustained blunt abdominal trauma. The accuracy of diagnostic peritoneal lavage in such patients has ranged from 88.5% as reported by Olson and Hildreth in 1971 to 100% as reported by Civetta and colleagues in 1970.[11,12] In 31 collected series involving 10,358 patients in whom diagnostic peritoneal lavage was used to evaluate *blunt* trauma to the abdomen, the overall accuracy rate was 97.3%.[13] The false positive and false negative rates were 1.4% and 1.3%, respectively. The complication rate for lavage was less than 1%. Most importantly, it was highly accurate when negative, providing strong evidence that there was no significant intraperitoneal injury.

The first attempt to use peritoneal lavage in a program of selective management of stab wounds to the abdomen was reported by Thal in 1977.[8] A total of 123 patients with stab wounds to the lower chest and anterior abdomen were evaluated using peritoneal lavage. The lavage was considered *positive* if there were greater than 100,000 red cells/mm³, greater than 500 white cells/mm³, or the presence of amylase, bile, or bacteria. If any of these criteria were met, the patient underwent immediate exploratory laparotomy; if not, the patient was admitted to the hospital for 24 hours of observation. Using this approach, 69.9% of patients were spared an exploratory laparotomy. The incidence of negative laparotomy was 4.1%. Two of 88 patients who were initially observed on the basis of negative clinical findings and a peritoneal lavage of less than 100,000 subsequently developed abdominal tenderness after admission and were explored. Both patients were found to have injuries to the small intestine (Table 3). A third patient in the group who initially had peritoneal lavage later became hypotensive and at the time of exploratory thoracotomy was found to be bleeding from an intercostal artery. An additional four patients had "false negative" lavages. One patient had a small bowel laceration and another patient had a serosal tear of the transverse colon. The range of red blood cell count for the hollow viscus injuries was from 380–68,000 red blood cells/mm³.

In an earlier report from our institution, 64 patients,

whose only indication for laparotomy was a positive wound exploration underwent peritoneal lavage prior to their laparotomy.[14] Six patients with a "negative" lavage, according to the above criteria, had significant intra-abdominal injuries. One patient with only 3,630 red blood cells/mm^3 of lavage fluid had a through and through stab wound to antrum of the stomach.

Thompson and co-workers at Denver General Hospital reviewed their experience with peritoneal lavage for stab wounds to the anterior abdomen (Table 3).[9] Fifty-seven patients with suspected penetrating abdominal stab wounds underwent diagnostic peritoneal lavage. Positivity was defined as over 100,000 red cells per mm^3. Thirty lavages (53%) were negative, five (9%) were termed "weakly positive", and 22 (38%) positive. All 22 patients with positive aspirates or lavages underwent laparotomy and significant visceral injuries were encountered in 20 patients (91%). Two of the five patients with a weakly positive lavage (50–100,000 RBCs/mm^3) and one of the 30 patients with negative lavages developed signs of peritoneal irritation and underwent exploration within 24 hours. The findings at laparotomy were a retroperitoneal hematoma, isolated gastric perforation, and single small bowel injury, respectively. The patient with the small bowel injury had less than 50,000 red blood cells/mm^3. The lavage results of the patient with the gastric perforation revealed a white blood cell count of 320/mm^3 and an amylase level of 16; that of the small bowel injury 10 white blood cells and an amylase of 74. The nonproductive laparotomy rate for the group undergoing diagnostic peritoneal lavage was 4% and the morbidity was 9%. There was no mortality.

Talbert and co-workers evaluated the role of peritoneal aspiration and peritoneal lavage in 32 patients with stab wounds below the fourth intercostal space (Table 3).[15] A positive study consisted of greater than 100,000 red cells per mm^3/, greater than 500 white cells per mm^3, or an amylase of 2½ times the normal serum values. Of the 28 patients with a lavage count of less than 100,000, one patient (lavage RBC 550/mm^3) subsequently developed fever and abdominal tenderness and required exploration. At the time of laparotomy, a contusion of the left transverse mesocolon and a hole in the left diaphragm were repaired.

If one combines the data from these reports, it appears that when peritoneal lavage was used as the primary diagnostic modality for all stab wounds, 5% of patients with counts less than 100,000 RBS/mm^3 required laparotomy for "missed" injuries to a hollow viscus. The role of peritoneal lavage in conjunction with physical examination and local wound exploration has not been well defined. Specifically, what is the sensitivity, and specificity of physical examination, local wound exploration, and peritoneal lavage? What should be their respective roles in evaluating patients with penetrating knife wounds to the anterior abdominal wall? The purpose of the present study was to address these questions and describe a plan, if possible.

TABLE 3. *Comparison of Studies Incidence of Hollow Viscus Injuries with Peritoneal Lavage Less than 100,000 RBCs/mm^3*

Study	Total No. Pts.	No. Hollow Viscus	Location of Injury	Lavage Results
1. Thal et al.	88	4 (5%)	small bowel	380 RBCs/mm^3
			small bowel	10,000
			small bowel	68,000
			transverse colon	3,000
2. Talbert et al.	28	1 (4%)	diaphragm and transverse colon	548
3. Moore et al.	35	2 (6%)	stomach	50,000–100,000
			small bowel	<50,000
4. Present Study	148	23 (16%)	16 stomach and small bowel	<100,000
			7 colon	(Table 3)
	299	30 (10%)	9 colon	

Silverstein and Gambino have described the technique for determining the accuracy and application of a clinical diagnostic test.[16] Sensitivity is defined as the true positives divided by the true positives *and* false negatives. Specificity is defined as the true negatives divided by the true negatives and false positives. When used as indications for laparotomy, highly sensitive tests assure safety of nonoperative management. Conversely, highly specific tests mandate exploratory laparotomy if positive.

Using the techniques of Silverstein and Gambino, a "positive" physical examination had a specificity of 99%. In only 1% of cases the physical examination was postive, but there was not a significant intra-abdominal injury. Three hundred eighty-seven patients with a "negative" physical examination underwent wound exploration. The sensitivity of wound exploration was 100% (*i.e.*, if the wound exploration was negative, none of the patients subsequently developed signs of intra-abdominal injury). The use of these two tests in combination (physical exam and local wound exploration) results in a clear, safe decision in well over one half of the patients.

The combination of physical examination and wound exploration provided insufficient information in the remaining 236 patients. One hundred fifteen of those patients had an intra-abdominal injury (true positive); 121 did not (false positive). Thus, the specificity was only 56%. This observation supports previous suggestions

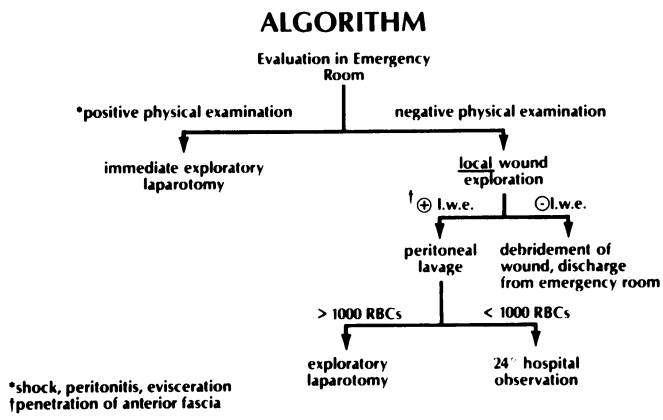

FIG. 2. Stab wounds of the anterior abdomen: algorithm.

that when wound exploration is positive, an additional modality such as peritoneal lavage should be added.

Therefore, the 236 patients in Group C (positive wound exploration) underwent peritoneal lavage followed by exploratory laparotomy. The utility of several "levels" of red blood cells/mm^3 lavage fluid was evaluated. There were 67 patients with less than 1,000 red cells. None were found to have an organ injury. There were no false negatives. The sensitivity was 100% and supports the safety of nonoperative management of these patients. If 50,000 red cells were used as a cutoff, the sensitivity changed to 70%, while the specificity increased to 94%. The high specificity supports laparotomy in these patients.

In the range between 1,000 and 50,000, there were 35 patients with significant organ injuries and 47 without. In this range, use of the lower limit results in an unsatisfactory specificity of 55%, but the upper limit leads to a potentially hazardous sensitivity of 40%. Thus, in this relatively small group (less than 20% of the entire patient population) a choice is necessary. Is the risk of a missed injury more important than the consequences of a nonproductive laparotomy?

The above question can be addressed by recognition of the fact that greater than half of the missed injuries would have involved a hollow viscus. Specifically, while there was only a 40% organ injury, 59% of these involved a hollow viscus (Table 2). When the analysis was broken down according to distribution of these hollow viscus injuries, of major concern is the fact that seven of the 21 were colon injuries. Despite current available therapy, peritoneal contamination secondary to hollow viscus injury is still the leading cause of infectious morbidity and mortality.[17] Since previous reports have demonstrated that infections occur in 12–72% of patients following colon injuries and mortalities range from 3–15%, recognition of these injuries should more than offset the risk of nonproductive laparotomy.[18–21]

It appears that solid organ injuries are more likely to bleed, in contrast to the hollow viscus injuries which appear to have less bleeding. The predominance of patients with such injuries had RBC counts of less than 50,000 in their lavage fluid. Thus, when added to local exploration, peritoneal lavage can be a predictor of the probability of organ injury and *suggests* the presence of hollow viscus injury at lower counts. This quantitative approach may provide better clinical guidelines than an approach that arbitrarily establishes a value that separates "positive" and "negative."

Algorithm for Management of Stab Wounds to the Anterior Abdomen (Fig. 2)

Based on the review of the literature and this current clinical series the following plan is proposed: (1) In patients who present with shock, peritoneal signs, or evisceration, neither wound exploration nor peritoneal lavage are indicated. Rather, the patient should undergo exploratory laparotomy with the expectation that 99% will have an intra-abdominal injury. (2) Patients without shock, evisceration, or evidence of peritonitis should undergo wound exploration by the surgeon responsible for his care. If there is no evidence for fascial penetration, the patient can be discharged after appropriate wound management, with no expectation for intra-abdominal pathology. (3) If fascial penetration is found at wound exploration, the patient should undergo peritoneal lavage by the hemostatic technique described above. (4) If there are less than 1,000 red cells per mm^3 of lavage fluid and the white blood cell count, bilirubin, amylase, and Gram's stain are also negative they should be admitted to the hospital for 24 hours of observation, but immediate laparotomy is unnecessary. (5) If the lavage fluid contains greater than 50,000 red cells/mm^3 the patient should undergo prompt exploratory laparotomy with the expectation that an intra-abdominal injury (probably to a solid organ) is likely. (6) Those patients who have between 1,000 and 50,000 red cells/mm^3 should also undergo exploratory laparotomy because of the high probability of injury to a hollow viscus.

Summary

Physical examination, local wound exploration, and peritoneal lavage can be incorporated into a specific program for selective management of stab wounds to the abdomen. When positive, physical exam predicts intra-abdominal injury in 99% of patients. When negative, local wound exploration rules out intra-abdominal injury in 100% of patients. However, when positive, local wound exploration has a low specificity and predicts intra-abdominal injury only 56% of the time. Therefore, peritoneal lavage becomes applicable to patients who

have a "negative" physical examination but "positive" local wound exploration. A red blood cell count of greater than 50,000 in the lavage fluid is predictive of organ injury. Counts between 1,000 and 50,000 suggest the presence of hollow organ injury. Counts less than 1,000 justify nonoperative management. Application of this plan for management of abdominal stab wounds should result in less than 10% nonproductive laparotomies and no missed injuries.

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Discussion

DR. GEORGE JORDON, JR. (Houston, Texas): It was really not too many years ago that most surgeons explored all patients who had a wound that penetrated the anterior fascia, but it has become obvious that selective treatment of these patients is desirable, as many of them do not have intra-abdominal organ injuries.

We, some years ago, began to use local wound exploration, as indicated by these authors, to exclude the group that did not have penetration of the peritoneal cavity, and we continue to do so. We also began a similar, though not identical, study to this, under the direction of Dr. David Feliciano, of our department, approximately 3 years ago, and in 1981 and 1982 we treated 531 patients who had penetrating wounds of the abdominal cavity.

As in this group, 55% of these patients had clinical evidence of difficulty within the abdomen, leading to immediate exploration, and the remaining were subjected to peritoneal lavage. There were 244 such patients.

We did not break our patients down quite as specifically as this group did. We used the same parameters, but explored the patients only if they had red cell counts more than 100,000/mm^3, an elevated white count, an elevated amylase, or a positive Gram's stain. Using these modalities, we immediately identified 87 patients who did go to operation, and who did have intra-abdominal injuries.

We had six patients, however, in whom the lavages on these criteria, were negative, and who subsequently came to operation because of development of clinical abdominal findings. We, therefore, have continued to use a higher level of red cell count than the current authors as an indication for surgery, and believe that in our 531 patients there has only been one patient who may have been operated on unduly late, on the basis of the protocol that we have followed.

We agree, therefore, that peritoneal lavage is an important aspect of the evaluation of patients with stab wounds of the anterior abdominal wall, and that it will result in more prompt entry into the surgical suite for patients who have severe injuries.

DR. ERWIN THAL (Dallas, Texas): We support Dr. Oreskovich's and Carrico's clinical approach utilizing physical examination, local wound exploration, and peritoneal lavage. This combination serves as an excellent compromise between those who advocate mandatory exploration and those recommending selective management. We would, however, question the necessity of using such a low cell count as an indication for operation.

Initially, the authors suggested using 50,000 cells. In Brooklyn it is 20,000; in Denver it is 5000. Today we have been told it should be 1000. Are we putting too much emphasis on a simple adjunctive procedure? The authors stated that 60% of patients with cell counts between 1000 and 50,000 with visceral injuries had hollow organ involvement, an impressive list. It is noted, however, that 57% of the patients in this group, 1000 to 50,000, had no evidence of injury at operation.

We recently reviewed our experience with 328 patients, using 100,000 red cells as the indication for celiotomy. Of the 185 patients who were lavaged, there were eight false negatives, or 4.3%. There were two hollow viscus injuries, and neither involved the colon. 2 patients, 1.1%, had complications due to a delayed operation. It is of interest that two of the eight patients with injuries had cell counts of 42 and 286, well below the authors' recommended 1000.

We had 36 patients with anterior stab wounds and cell counts between the 1000 and 50,000, with only 2 false negatives. The negative celiotomy rate for this group was 9.6%, as compared with the 57% reported today.