

# Negative Laparotomy in Trauma: Are We Getting Better?

BEAT SCHNÜRIGER, M.D., LYDIA LAM, M.D., KENJI INABA, M.D., LESLIE KOBAYASHI, M.D.,  
RAFFAELLA BARBARINO, M.D., DEMETRIOS DEMETRIADES, M.D., PH.D.

*From the Division of Acute Care Surgery (Trauma, Emergency Surgery and Surgical Critical Care)  
University of Southern California, LAC+USC Medical Center, Los Angeles, California*

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One of the trauma surgeons' daily challenges is the balancing act between negative laparotomy and missed abdominal injury. We opted to characterize the indications that prompted a negative trauma exploratory laparotomy and the rate of missed abdominal injuries in an effort to optimize patient selection for laparotomy. At the Los Angeles County + University of Southern California Medical Center, negative laparotomies and missed injuries are consecutively captured and reviewed at the weekly mortality + morbidity (MM) conferences. All written reports of the MM meetings from January 2003 to December 2008 were reviewed to identify all patients who underwent a negative laparotomy or a laparotomy as a result of an initially missed abdominal injury. Over the 6-year study period, a total of 1871 laparotomies were performed, of which 73 (3.9%) were negative. The rate of missed injuries requiring subsequent laparotomy was 1.3 per cent (25 of 1871). The negative laparotomy rate and the rate of missed injuries did not vary significantly during the study period (2.8 to 4.7%,  $P = 0.875$ , and 0.7 to 2.9%,  $P = 0.689$ ). Penetrating mechanisms accounted for the majority of negative laparotomies (58.9%). The primary indication for negative laparotomy was peritonitis (54.8%) followed by hypotension (28.8%) and suspicious computed tomographic scan findings (27.4%). The complication rate after negative laparotomy was 14.5 per cent, and of these, 10.1 per cent were directly related to the procedure. A low but steady rate of negative laparotomies and missed abdominal injuries after trauma remains. Negative laparotomies and missed abdominal injuries when they occur are still associated with significant complication rates and a prolonged length of stay.

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ONE OF THE TRAUMA surgeons' daily challenges is the balancing act between negative laparotomy and missed abdominal injury. The negative impact of a missed injury on outcomes can be significant; however, an overly aggressive approach is associated with negative laparotomy with the potential for concomitant surgical-related morbidity. At Los Angeles County + University of Southern California (LAC+USC) Medical Center, a selective nonoperative approach for all trauma patients sustaining abdominal trauma is used. The purpose of this review was to provide a contemporary assessment of our rate of negative laparotomies and missed injuries.

The optimal timing and indications for exploratory laparotomy in penetrating or blunt trauma continues to

be elusive, and the decision to go the operating room remains a challenging diagnostic dilemma for surgeons. Commonly accepted indications for exploratory laparotomy include peritonitis on examination, hypotension in penetrating abdominal trauma, and hypotension combined with free fluid visualized with ultrasonography for blunt trauma. These criteria, however, still result in false positive and negative laparotomies. The reported incidence of negative laparotomies in trauma ranges from 6 to 36 per cent.<sup>1-5</sup>

Missed injuries and delays in treatment may lead to life-threatening complications as well as prolonged hospital stays.<sup>6</sup> Because of this, many advocate a liberal policy of exploratory laparotomy, especially in smaller hospitals where full-time housestaff are not available to perform serial clinical and laboratory examinations.

However, negative laparotomies are not without morbidity and, even if the postoperative course is uncomplicated, can cause significant discomfort, poor cosmesis, and prolongation of hospitalization. Because of this, we sought to characterize those patients undergoing a negative laparotomy at our institution and

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Address correspondence and reprint requests to Kenji Inaba, M.D., 1200 North State Street, Inpatient Tower (C), 5th Floor, Room C5L100 Los Angeles, CA 90033-4525. E-mail: kinaba@surgery.usc.edu.

examine their indications for surgery and postoperative complications. The rate of missed injuries and resultant complications was analyzed as well. We hypothesize that technological and clinical improvements in recent years have been able to further decrease the rate of negative laparotomies.

### Patients and Methods

At LAC+USC, negative laparotomies and missed injuries are captured in real time by a team of trained nurses and reviewed at the weekly mortality + morbidity (MM) conference. After Institutional Review Board approval, all written reports of the MM meetings over a 6-year study period (January 2003 to December 2008) were retrospectively reviewed to identify all patients who underwent a negative laparotomy or a laparotomy resulting from an initially missed abdominal injury. A negative explorative laparotomy was defined as a laparotomy without any evidence of intra-abdominal injury. The operative and discharge reports of these patients were then reviewed. A computerized spreadsheet (Microsoft Excel 2003; Microsoft Corporation, Redmond, WA) was created to abstract the following variables for each of these patients: age, gender, mechanism of injury, vital signs and Glasgow Coma Scale (GCS) on admission, Abbreviated Injury Scale (AIS) for face, head, abdomen, chest, and extremities, Injury Severity Score (ISS), indication for laparotomy, and in-hospital complications. Continuous variables were dichotomized using clinically relevant cut points: systolic blood pressure (SBP) (less than 90 mm Hg, GCS 8

or less, chest, head, abdomen and extremity AIS (3 or greater).

Continuous variables, times, and categorical variables are reported as means  $\pm$  standard deviation (SD), means  $\pm$  interquartile (IQ) range, and percentages, respectively. *P* values were obtained from Mann-Whitney *U* test for continuous variables. Data were analyzed using the statistical package SPSS (Version 16.0; SPSS Inc). *P*  $\leq$  0.05 was considered significant.

### Results

#### *Incidence of Negative Laparotomies and Laparotomies Resulting from Missed Abdominal Injuries*

From January 2003 to December 2008 a total of 1871 laparotomies were performed as a result of trauma. Of these, 3.9 per cent (73 of 1871) were negative and 25 (1.3%) were the result of initially missed abdominal injuries. The negative laparotomy rate and the rate of initially missed injuries did not vary significantly during the study period (2.8 to 4.7%, *P* = 0.875, and 0.7 to 2.9%, *P* = 0.689) (Fig. 1). The 25 missed abdominal injuries requiring laparotomy consisted of 17 hollow viscus injuries (including three ureter lacerations and two mesenteric tears), three solid organ lesions (two pancreatic and one splenic laceration), three diaphragmatic perforations, and two vascular lesions. The mean time to laparotomy for patients with missed abdominal injuries was 4.6 (IQ, 1.0 to 8.0) days from admission.

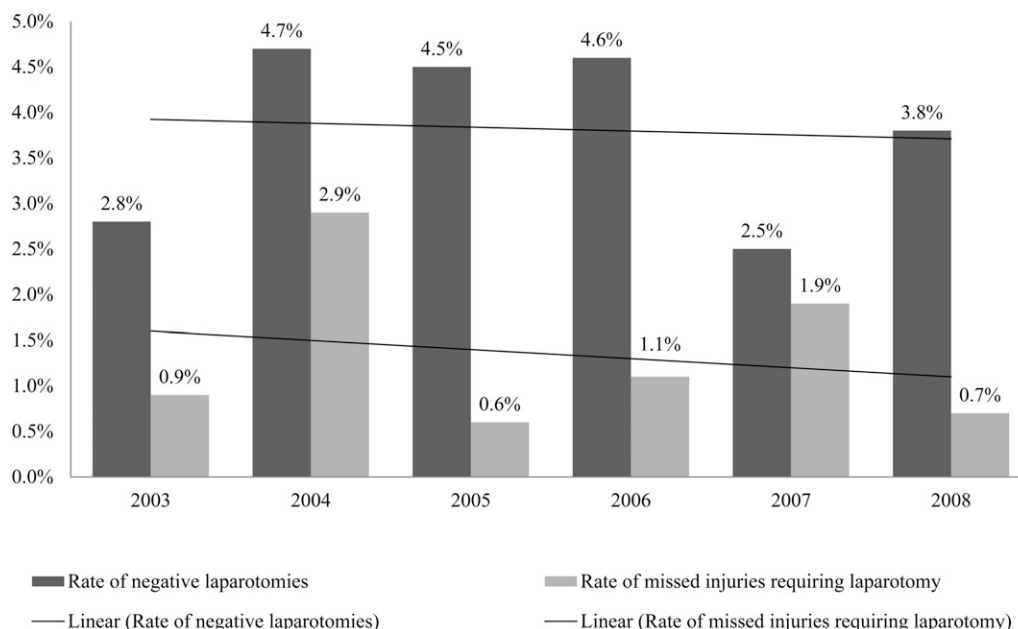


FIG. 1. Rates of negative laparotomies and laparotomies resulting from missed injuries over the study period.

### Characteristics of Patients Undergoing Negative Laparotomy

The mean age of patients undergoing negative laparotomy was  $35.2 \pm 15.7$  years and 65 (89.0%) were male (Table 1). The mean ISS was  $12.0 \pm 11.6$ . Overall, 46 of 73 patients (63.0%) had severe (AIS 3 or greater) concomitant injuries to the head, chest, or extremities (Table 1). Hypotension (SBP less than 90 mm Hg) on admission was documented in six of 73 (8.2%) patients (Table 1).

Mechanism of injuries included 26 (35.6%) motor vehicle accidents, 23 (31.5%) stab wounds, 20 (27.4%) gunshot wounds, three (4.1%) falls, and one (1.4%) blunt assault. Multiple stab or gunshot wounds were seen in 14 of 43 patients with penetrating injuries. The documented sites of the abdominal penetrating injuries were left and right upper quadrant (each  $n = 5$ ), left lower quadrant ( $n = 5$ ), right lower quadrant ( $n = 3$ ), and flank and back ( $n = 4$ ). In seven patients, the site of the penetrating injury was not available.

A total of 131 indications led to 73 negative laparotomies. Peritonitis was the most frequent indication accounting for 54.8 per cent ( $n = 40$ ) of cases. The next most frequent indications for laparotomy were transient hypotension in 28.8 per cent ( $n = 21$ ) and suspicious computed tomographic scan findings in 27.4 per cent ( $n = 20$ ) (Table 2).

### Hospital and Intensive Care Unit Length of Stay

For patients who underwent negative laparotomy, hospital length of stay was significantly dependent on whether complications occurred ( $18.4 \pm 18.2$  vs  $7.3 \pm 8.2$  days,  $P = 0.026$ ). Furthermore, the presence of associated extra-abdominal injuries increased hospital

length of stay significantly ( $13.5 \pm 14.0$  vs  $8.6 \pm 18.0$  days,  $P < 0.001$ ). A total of 26 (35.6%) patients had at least 1 day of intensive care unit (ICU) stay after the negative laparotomy.

Mean hospital and ICU length of stay for patients with missed abdominal injuries was significantly longer when compared with patients who underwent negative laparotomy ( $36.6 \pm 68.0$  and  $18.0 \pm 39.7$  days vs  $10.9 \pm 15.9$  and  $4.4 \pm 9.6$  days,  $P = 0.002$  and  $P = 0.049$ ). Again, in this group of patients with missed injuries, complications significantly prolonged hospital length of stay ( $103.3 \pm 117.0$  vs  $14.3 \pm 11.5$  days,  $P < 0.001$ ).

Four of 73 patients undergoing negative laparotomy were transferred postoperatively to another hospital and therefore no follow-up could be obtained. Of the remaining 69 patients, 55 (79.7%) had an uneventful postoperative in-hospital course. Ten of 69 (14.5%) patients had 12 different complications (Table 3). Complications resulting from the negative laparotomy occurred in seven of 69 (10.1%) patients. These included wound infections ( $n = 3$ ), persistent postoperative abdominal pain ( $n = 2$ ), iatrogenic splenic injury ( $n = 1$ ), and a wound hematoma with delayed bleeding ( $n = 1$ ) (Table 3).

Of the 25 patients undergoing laparotomy for missed injury, four (16.0%) sustained subsequent infectious complications (one wound infection and three severe abdominal sepsis resulting from one missed colon injury and three resulting from missed small bowel perforations) (Table 4).

A total of four patients who underwent negative laparotomy died. Two deaths occurred early (within 24 hours) and two delayed (after 24 hours). Of these four

TABLE 1. Demographics and Vitals on Admission of the 73 Patients Receiving Negative Laparotomies

Age (years; mean $\pm$ SD)	$35.2 \pm 15.7$
Male	65 (89.0%)
Penetrating injury	43 (58.9%)
ISS (mean $\pm$ SD)	$12.0 \pm 11.6$
SBP (mm Hg) on admission (mean $\pm$ SD)	$119 \pm 30.4$
Number of patients with a SBP on admission $<$ 90 mm Hg	6 (8.2%)
Number of patients with AIS head 3 or greater	15 (20.5%)
Number of patients with AIS chest 3 or greater	25 (34.2%)
Number of patients with AIS extremity 3 or greater	15 (20.5%)
GCS	$13.2 \pm 3.7$
Number of patients with GCS 8 or less	6 (8.2%)

SD, standard deviation; ISS, Injury Severity Score; SBP, systolic blood pressure; AIS, Abbreviated Injury Score; GCS, Glasgow Outcome Score.

TABLE 2. Indications for the 73 Negative Laparotomies

Indication	No. (%)
Peritonitis	40 (54.8%)
Transient hypotension	21 (28.8%)
Suspicious CT scan (free air, fluid, bowel wall thickening)	20 (27.4%)
Suspicious site of stab or gunshot wound	17 (23.3%)
Unevaluable as a result of traumatic brain injury	9 (12.3%)
Sepsis of unknown origin, increasing WBC count	7 (9.6%)
False positive FAST	7 (9.6%)
Unevaluable as a result of intoxication	4 (5.4%)
Omental evisceration	3 (4.1%)
Positive DPA	2 (2.7%)
Decreasing hemoglobin or hematocrit level	1 (1.4%)
Total	131

CT, computed tomography; WBC, white blood cell; FAST, focused assessment with sonography for trauma; DPA, diagnostic peritoneal aspiration.

TABLE 3. *Complications after Negative Laparotomy (n = 73)*

Complication	No.
Wound infection (one associated with fascial dehiscence)	3
Pneumonia	2
Persistent pain of unknown origin	2
Intraoperative, iatrogenic splenic injury requiring splenectomy	1
Wound hematoma and bleeding requiring surgical intervention	1
Heparin-induced thrombocytopenia	1
<i>Clostridium difficile</i> enteritis	1
Acute respiratory distress syndrome	1
Total complications	12

TABLE 4. *Complications after Laparotomies Resulting from Missed Abdominal Injuries (n = 25)*

Complication	No.
Abdominal sepsis	3
Wound infection	1
Total complications	4

deaths, three were the result of severe brain injury and one resulting from multiple organ failure in a cirrhotic patient after 30 days in the ICU.

Of the 25 patients undergoing laparotomy for missed injuries, one patient died after a prolonged hospital stay complicated by abdominal sepsis, pulmonary embolism, and multiple organ failure after having a delayed small bowel injury repaired on Day 7 after admission.

### Discussion

Historically, wide variability has existed in the reported incidences of negative or nontherapeutic laparotomy after trauma.<sup>1, 3, 5, 7-10</sup> Most surgeons felt it was better to be safe than sorry with the threat of missed injury far outweighing the theoretical risks related to a negative laparotomy. However, with the rise of selective nonoperative management, the increasing use of modern imaging technologies, and the era of pay for performance, it is becoming increasingly important to avoid unnecessary procedures and health-care expenditures.

In 1993 Henderson et al.<sup>5</sup> looked retrospectively at 525 laparotomies for trauma and found a negative and nontherapeutic laparotomy rate of 36 per cent. This decreased to 6 per cent in a large retrospective analysis from Baltimore only 10 years later in 2003.<sup>3</sup> This dramatic decline in negative laparotomies was likely the result of several factors, including improved ICU care, more liberal policies of nonoperative management for solid organ injury, and improvements in the accuracy of imaging technology. We sought to determine

if technological and clinical improvements in the subsequent years have been able to decrease this negative laparotomy rate even further.

This current study at a busy urban Level I trauma center found a negative laparotomy rate of almost 4 per cent, which compares favorably to prior studies at similar centers.<sup>1, 3, 5</sup> It also compares favorably to prior studies of our own, in which we reported incidences of nontherapeutic operations of 22 and 12 per cent.<sup>2, 4</sup> These results, however, cannot be compared with the ones presented here, because “nontherapeutic” laparotomies were also included. Although the current study continues the downward trend in negative laparotomy rates at our institution, rates of negative laparotomies were not significantly different within the study period, suggesting that these improvements may be reaching a plateau.

With more patients being managed nonoperatively, there is always a danger of delay in diagnosis and missed injury. However, in the present study, the rate of laparotomy for missed injury was low at 1.3 per cent. This is comparable to a previous study from this institution reporting a delayed laparotomy rate of 4 per cent<sup>11</sup> and to rates described in the literature, which range from 2 to 7 per cent.<sup>12, 13</sup>

In this study, blunt mechanisms of injury accounted for 41 per cent of patients. This is in contrast to the bulk of previous negative laparotomy studies, where penetrating mechanisms far outweighed blunt mechanisms. This may be the result of the evolution of selective nonoperative management also for penetrating trauma.<sup>7, 11, 14</sup>

The majority of patients undergoing negative laparotomy were taken to the operating room based on the clinical evidence of peritonitis. This finding is similar to a recent prospective study of penetrating trauma that found peritonitis alone was relatively insensitive as a predictor of intra-abdominal injury, resulting in a nontherapeutic laparotomy rate of 29 per cent.<sup>1</sup> It is difficult to differentiate peritonitis from the diffuse muscular pain occurring after trauma.

Suspicious computed tomographic (CT) scan findings were the second most commonly noted indication for laparotomy in this study. This is in keeping with other studies that also found a significant number of negative laparotomies, 24 per cent, based solely on CT findings.<sup>1</sup> Although the accuracy of CT scans in trauma continues to improve, with sensitivities and specificities greater than 95 per cent in one study of penetrating torso trauma,<sup>15</sup> it appears that there is still room for improvement.

Complication rates after negative laparotomy range widely in the literature, from a low of 2 to 3 per cent up to 37 per cent based on multiple retrospective studies.<sup>3, 5, 8-10, 16-20</sup> Our current study found a 10 per

cent complication rate directly related to the negative laparotomy. These rates of complications are similar to previous investigations, suggesting that the risk of these complications may be intrinsic to laparotomy itself and not related to technique or patient demographics.

The mortality rates in the negative laparotomy and missed injury groups were similar to the ones reported by previous investigators.<sup>3, 5, 8, 10, 20</sup> However, care must be taken when comparing patients with negative laparotomies with patients undergoing laparotomy for missed injuries, because these are heterogeneous populations. A recent study compared patients with delayed laparotomies to those with negative laparotomies.<sup>6</sup> These investigators found, in contrast to our study, that a significantly increased rate of complications occurred among patients with delayed laparotomies with a mortality rate of 14 per cent. The authors' conclusion was that perhaps the pendulum has swung too far toward nonoperative management in their center.<sup>6</sup> In contrast, the present study finds that an aggressive strategy of nonoperative management for appropriate patients results in a low (1.3%) rate of missed injuries and that these patients experience no greater risk of complications compared with patients undergoing negative laparotomies. One reason for the difference in complications and mortality may be a shorter delay in diagnosis in our study compared with the previously mentioned study (4.6 days [IQ, 1.0 to 8.0] vs 7 ± 9 days).<sup>6</sup>

The limitations of this analysis are inherent to any retrospective study with the possibility of reporting bias. The retrospective nature of the study also precludes our ability to determine why our current length of stay is longer than our own historical rates or rates in comparable studies.

### Conclusion

A low but steady rate of negative laparotomies after trauma remains. Furthermore, the missed abdominal injury rate remains low. However, negative laparotomies and missed abdominal injuries, when they occur, are still associated with significant complication rates and a prolonged length of stay.

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