

particularly associated injuries, or to selective tolerance of a lower value of hemoglobin before transfusion.<sup>19</sup>

Based on our results, we agree that the abdominal CT scan is useful to recognize and categorize the degree of splenic injury, although CT scan tends to underestimate the severity of injury when compared to grading at operation. The present injury scoring systems used for CT grading of injuries do not address the issue of longitudinal fractures of the spleen, which may be less likely to stop bleeding without operative treatment. Computed tomography may fail to detect coexistence abdominal injuries, hence strict attention to patient assessment and changes in condition is necessary to identify the patient who needs operation for reasons other than splenic injury. Given comparable degrees of injury, children seem more likely to be managed successfully without operation than adults. Identification of major splenic injuries on CT (grade 4 for children, grade 3 for adults) should lead to prompt operation rather than observation, even though the patient's condition appears stable. Age is another important factor that must be considered when management decisions are made. We believe that these issues and future developments in the diagnosis, classification, and management of blunt splenic trauma will further refine the treatment of splenic injury.

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## DISCUSSION

DR. JOSEPH A. MOYLAN (Durham, North Carolina): We, too, are concerned about the use of CT in the adult patient. Our experience, like yours, has shown that it not only underestimates the severity of injuries in adults but actually has missed many important injuries. Our series of more than 40 adult patients during the past several years in which an abdominal CT was used because the patient, who was more than 12 hours after injury and stable, or had a contraindication to diagnostic peritoneal lavage.

In that series there were six false-negative exams in patients with multisystem injuries and closed head injuries did not present with abdominal findings. Two had serious colon injuries. Two had serious small bowel injuries. One had a bleed from a delayed mesenteric artery transection, and one had a bleed from an injured spleen on day 3.

We think that CT, if widely used in the adult, may delay diagnosis of

serious injuries, particularly of the hollow viscus in the abdominally injured patients, leading to prolonged severe septic complications and hemorrhagic complications. I have three questions for Mark.

First, what defines an adequate abdominal CT? Does this include both oral and intravenous contrast material? Clearly in some of the series in which missed injuries have been reported, both routes, oral and intravenous contrast, have not been used.

Second, you mentioned in your abstract that there were some shortcomings in terms of missed injuries. Do you have any other missed injuries other than the pancreatic injury that was reported in the abstract?

Finally, if you think that hemoperitoneum is an indication for operative intervention in the adult patient, shouldn't you use a diagnostic peritoneal lavage even after a period of stability rather than an abdominal CT?

DR. ALEX HALLER (Baltimore, Maryland): It has been very interesting during the last several decades to watch the evolution of management

of splenic injury, both from the battlefield and also from the sidelines. Although Dr. Feliciano correctly pointed out that the first evidence that removing the spleen would significantly alter immunologic function was in rats, this data did not catch my attention nearly so much as when one of our members, Dr. Harris Shumaker, pointed out in children that there was a significant immunologic deficit after removal of the spleen for hematologic abnormalities. That observation was in 1952. So 37 years ago we were alerted to the fact that splenectomy might create problems. What we have heard today is an evolution of this concept of SOS—save our spleens—because this concept also applies to teenagers and young adults.

Just as in our experience 4 years ago when we studied a group of children prospectively using CAT scanning, the authors had very few false-negative or false-positive results. As a matter of fact, in our experience with 84 children who were prospectively studied, and who were unconscious with Glasgow Coma scores under 10, we found that there were no false-positive and two false-negative results, both of whom subsequently were found to have a ruptured small intestine. This complication was picked up in the intensive care unit where they were under constant observation and they were subsequently operated on.

I am delighted that this symposium is discussing techniques of splenorrhaphy, which would have been unheard of at the Southern Surgical a decade ago. Now we are looking at selective management because, in Dr. Spencer's series, these patients selected themselves. The majority of those patients could have been managed during one first golden hour without operative intervention had we the data and the courage to go forward with that approach.

I would like to ask the authors of the paper from Louisville whether they believe that, on the basis of this experience, they still need to use diagnostic peritoneal lavage? If you identify blood in the peritoneal cavity but you are not going to operate on those patients if they are hemodynamically stable, why do the lavage? If you are going to follow those patients on the basis of their hemodynamic status, then you don't need to know whether there is blood in the peritoneal cavity.

We use peritoneal lavage only in patients who are hemodynamically stable and need to go immediately to the operating room for another indication under anesthesia. Then we will do the peritoneal lavage in the operating room. If it is positive, we will also carry out a laparotomy.

In Louisville, are you using peritoneal lavage now that you have the CT scan protocol for this group of patients? And if so, what are the indications?

**DR. RICHARD BELL** (Columbia, South Carolina): It still appears to me that the preferred method for abdominal evaluation in the bluntly traumatized individual remains controversial. Both diagnostic peritoneal lavage and computed tomography have advantages as well as pitfalls. Perhaps the advantages offered to us by the new generation of CT scanners will obviate the present problems and improve the precision of diagnosis.

This may increase our ability to determine not only injury to an organ but also the degree of injury. Once this can be accomplished, we may be able to develop a rational basis for therapeutic decisions rather than relying on incomplete information, tradition, or personal or institutional bias.

The work by the Louisville group suggests that a quantitative guide to determine selective management of splenic injury should be developed, prospectively studied, and validated. Little work to date has been done in this area and the authors have retrospectively reviewed their clinical efforts with thoroughness, thoughtfulness, and caution.

It is always a pleasure to comment on work that supports my own bias. Our experience at the University of South Carolina is similar, suggesting that there are differences in the injured adult patient with respect to the spleen.

A cursory review of 108 splenic injuries in our adult patients from 1985 to 1988 reveals that 45% had an additional intraperitoneal or retroperitoneal injury, which we considered surgically significant.

Splenic injury in adults appears to be a different disease than in children. As aptly demonstrated by this report, the data suggest that the failure rate of conservative nonoperative observation in adults is twice what was reported in the pediatric population, even though the splenic injury severity score was less in the adult population.

I have several questions for the authors. Because computed tomography underestimated the degree of splenic injury as determined at the time

of surgery in 9 of 17 patients, can we assume that it underestimated the degree of injury in those who did not fail the trial of nonoperative therapy, and if so, is this of any clinical concern?

Second, the group that underwent operative intervention received more blood than the observed group. Was this due to a more serious splenic injury resulting in greater blood loss, associated injuries, or both?

As the authors suggest in their manuscript, would the determination of the axis of splenic injury modify the approach to management? Dr. Malangoni and his coworkers have suggested a potential clinical difference with respect to blood loss between horizontal and longitudinal lacerations to the splenic pulp.

Should we take cuts with smaller intervals through the spleen with our scanners?

Was there any additional morbidity or mortality associated with subsequent operative intervention imposed by the delay itself on those who failed observation, and did this influence your ability to perform splenic salvage operations?

Finally, in many centers radiologists are not always available 24 hours a day to render an opinion. At 2:00 A.M. the surgeon must make the decision to observe or to operate without the interpretation offered by a radiologist. Can you comment on this aspect of your study? Specifically, is there a difference between what the radiologist sees, often in retrospect, compared to the nonradiologist, and would this difference influence decision making?

I think the work points out that splenic injuries are not identical in adults and children. In many cases splenic salvage for adults may be best accomplished in the operating theater.

**DR. JAMES O'NEILL** (Philadelphia, Pennsylvania): I congratulate Dr. Malangoni for his presentation and, as a general surgeon with special interest in children, I thought it might be interesting to share some of our own experience with this technique.

Diagnostic peritoneal lavage has gone out of use with very few exceptions in our center, primarily children with overwhelming head injuries and that rare group that has hypotension without obvious hemorrhage.

We have recently studied 123 consecutive patients who had splenic injuries, all of whom were evaluated by computed tomography with double-contrast technique.

It is of interest that 70% of these patients were treated without operation, and this may suggest that there is a difference in children as compared to adults. But as consider what I have heard today, which is remarkable to someone interested in children, when you think back to the time when many people thought that spleens should always be removed, I am not so sure that children are necessarily so different. It may be that surgeons are different in their approach to the patient and their degree of confidence in observation of such patients. Only time will tell whether that is the case or whether, indeed, adults have less tendency to vasoconstriction at the splenic level or not.

So 30% of our patients were operated on and only three in the last 9 years have had splenectomy. No patient has had arterial ligation, and we certainly wouldn't select that if we could avoid it.

Almost all our patients have had blunt injuries. Many of our patients have been found to have splenic injury when they were suspected not to have splenic injury from the use of computed tomography, and it is not surprising that many of those patients did very well indeed. Overall it has been a 95% salvage rate as we have looked at patients with splenic injuries in the last several years.

We have not found that it is necessarily valid to conclude that a grade IV injury cannot be treated by observation because of the periodic observation of patients who have been admitted 3 days or so after injury with grade IV injuries. Even though it has been stated that CT may underestimate the nature of a splenic injury, it is the stability of the patient, combined with that radiographic observation, that determines what we do.

I have a question that is a little different from any of the other issues raised this afternoon, and it has to do with postoperative management.

Some experimental evidence from our own laboratory and the laboratories in Buffalo suggest that if you have more than a third of your splenic mass you are probably protected, provided that you have splenic artery supply to that splenic remnant. So we have taken the point of view that if you have one half or more of your spleen, you probably don't need immunization, but if we have patients with less than 50% of

splenic mass, whether they are being observed or they have been operated on, we have immunized them with both pneumococcal and H flu vaccine and protected them with oral penicillin.

I would ask Dr. Malangoni whether he shares any of these experiences and what he thinks about immunization for such patients after operation, whether they are children or adults.

**DR. THOMAS A. GASKIN, III** (Birmingham, Alabama): We have all struggled among surgeons to try to develop an algorithm to minimize the adverse outcomes in splenic injuries. You have introduced a new variable and the variable is radiographic interpretation, whether by a surgeon or a radiologist.

I would like to invite an analogy with the receiver operator curve concept in mammography and how to approach decisions using that concept.

**DR. CHARLES G. WARD** (Miami, Florida): I was struck by Dr. Haller's comment about how concepts have changed in the past 10 years. I would ask the authors of these three excellent papers to continue to look at their patients 10 years hence and see if those who received herniorrhaphy really fall back in the normal category with the instance of sepsis.

**DR. M. A. MALANGONI** (Closing discussion): Dr. Moylan pointed out that the technique of CT is extremely important and we would agree that the administration of both oral and intravenous contrast is necessary for an adequate examination. If that is not done, the error rate will increase accordingly. The only missed injury we had in our patient population was the pancreatic injury, and that was picked up by repeated exam and continued monitoring of the patient. We can't forget that this needs to be done after the CT is completed.

We do CT scans only for patients who have localized findings and in those in whom we suspect that splenic injury is the only abdominal organ injury or for those patients in whom diagnostic peritoneal lavage is contraindicated. We do not routinely use CT scans to evaluate our other abdominal trauma patients.

This leads me into the provocative questions that Dr. Haller asked. Most of our patients with hemoperitoneum have injuries other than to the spleen, so therefore we only use the CT, as I mentioned, and we continue to use diagnostic peritoneal lavage preferentially in our adult patients. That is not the case, however, in the children with splenic injury. As I mentioned, it is part of our management protocol to do CTs in those patients, except in those who have demonstrated persistent he-

modynamic instability in whom it is better to operate immediately rather than to spend some time in the CT scanner.

I should mention that our goals of nonoperative management are to select those patients who will stop bleeding spontaneously, and I would add that the goals of operative management are to select those patients who will not stop bleeding by some other means. Therefore the goal is really the same, and that is to stop bleeding in these cases. We think that nonoperative management is best done by evaluating the patient's overall condition, the condition of the splenic injury, and the patient's age.

Dr. Bell asked about underestimation of injury by the CT and what we should do about it. I believe that is an unanswerable question and is not really clinically important to us. He did emphasize the importance of longitudinal fractures and we believe that you have to interpret the direction of the fracture on CT. The longitudinal fracture that crosses the trabecular vessels of the spleen is more likely to bleed persistently and not be amenable to nonoperative management. Indeed our patients who had greater degrees of blood loss had greater degrees of splenic injury, as injury severity scores were similar.

The patients who had longitudinal fractures failed more often, and I don't think a change in scanning technique is necessary. It is the interpretation that is the key here. We did not incur any additional morbidity or mortality in these patients with delayed treatment. We did believe, however, that we were more likely to perform splenectomy at operation for those patients who failed because of the friable nature of the spleen at that point.

It is very important that you have someone who can interpret the scan on hand in the hospital, whether that be a radiologist or a surgeon. If neither of these people are present, then I suggest that you not do CT scans, which I believe answers Dr. Gaskin's question as well. That is, the CT has to be interpretable so you know what to do with the information.

Dr. O'Neill, we believe that children are different from adults and that the risk-benefit ratio for blood transfusion compared to overwhelming postsplenectomy infection seems to be different. There are clearly different results reported when children are followed for overwhelming postsplenectomy sepsis after splenectomy for blunt trauma compared to adults. This fact must be taken into account. We were not readily able to tolerate transfusion in our adult patients who were managed without operation, whereby in the management of children and teenagers we would tolerate a hemoglobin level as low as 8 with no transfusion, and we were able to manage some of these patients by that means. Our postoperative practices are the same as yours for children, and for adults we do not give antibiotics, but rather immunization.