types of trauma centers, including community hospitals, university hospitals and children's hospitals.[10,11,23] Sixty-two per cent (537/867) were not operated on with the following organ-specific break down of nonoperative management:

1. Spleen (151/235)
2. Kidney (101/136)
3. Liver (178/266)
4. Pancreas (12/19)
5. Multiple organs (95/211)

No exact cause of death can be obtained from the national registry; however, the vast majority of patients died from concomitant head injuries. This is not a precise comparable group of trauma patients because the data are not gathered prospectively and they are not from institutions which use the identical protocol we have recommended.[24] The National Pediatric Trauma Registry recorded a mean injury severity score[3] of 8 and a mean PTS[22] of 9, which suggests less severe trauma than our study group.[6]

Nevertheless, the low incidence of laparotomy (38%) in this national group and 12% (9/78) in our own carefully selected trauma patients, as well as the absence of any mortality related to the initial nonoperative management, have convinced us of the efficacy of this protocol. Therefore, we believe that, for children with blunt abdominal injuries, nonoperative management to solid organs is safe and appropriate if carried out under careful continuous surgical observation in a pediatric intensive care unit.

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Discussion

DR. EDWIN IDE SMITH (Dallas, Texas): It's interesting from a historical standpoint to realize that prior to World War II in Begger & Horsley's book on operative surgery, a selective including nonoperative approach to splenic injuries is recommended. It later changed with World War II. But the preservation of the spleen is important. But also is the avoidance of an unnecessary anesthesia and laparotomy, which lessens the metabolic stress—or the anesthesia and laparotomy would increase the metabolic stress on a potentially injured CNS system. And I think this is one area that needs considerably more

investigation. The approach recommended by Dr. Haller and his associates depends on an individualization of care which requires careful re-evaluation. It is the contrast of a knee-jerk response in which one does not continue observation. It acknowledges this limitation of attempting to make a definitive diagnosis immediately in the emergency room. Our own experience at UT Southwestern in a retrospective study recently done by Dr. Kevin Kadesky on 1222 patients over 28 months shows that our blunt injuries are remarkably similar with those at Hopkins. We had 28 splenic injuries and explored 14 of these, with 6 requiring splenectomy. We had 26 hepatic injuries with 7 explorations, and 10 renal injuries with only 1 exploration necessary. The only death in this group was a child who died in the emergency room minutes after being admitted with a massive hepatic injury. We had three intestinal injuries that were not detectable on CT scan, and I think this is a real concern and a weak point. But we feel that repeated flat and upright exams at 6 to 8 hours after initial examination proved to be very helpful in detecting free air and intestinal injury. So we would concur with Dr. Haller that this is a safe approach, given the proper safeguards and observation. It also depends on a need for imaging which is performed by experienced radiologists. I have several questions for Dr. Haller. They have a prohibition against blood transfusion, and is this absolute? In other words, in the presence of other injuries such as, say, bilateral fractured femurs, would they transfuse and still not explore? Second, what are your indications for exploration with pancreatic injury? Third, it has been our impression that splenic injuries seem to separate into two distinct groups: those that clearly require early exploration and are unstable, and the rest, which are usually stable and could be observed. Do you have this same impression? Lastly, what is your usual period of ICU observation in these children?

DR. RICHARD R. RICKETTS (Atlanta, Georgia): Dr. Haller has shown us today that nonoperative management of blunt trauma in children is safe when applying a strict protocol. In fact, his protocol is more stringent than most of us use. In the Toronto series, a nonoperative management of splenic trauma was allowed. The patient was allowed to receive ½ of his blood volume as blood replacement before surgery was entertained. Whereas, in Dr. Haller's series, they use the criteria of forty percent blood volume replacement with crystalloid. Our position at Egleston is somewhat in between. We allow a blood volume replacement of approximately 30% to 40% of the blood volume with blood before operating on otherwise healthy, hemodynamically stable patients. Our results at Egleston echo those of the National Pediatric Trauma Registry and of Dr. Haller. It was interesting, when I looked over these patients, that none of our multiple abdominal organ trauma patients were managed nonoperatively. In other words, they all required surgery, so I thought I'd look at those. And it's interesting that three of those four patients were injured by child abuse and that, also, that hollow viscera were involved as well. This tends to point out that while child abuse is an infrequent cause of trauma, it is frequently a cause of major trauma in children, and I wonder if Dr. Haller's experience is similar. While there seems to be universal agreement in the nonoperative management of splenic and renal injuries, there is still some controversy about the nonoperative management of liver injuries.

A few years ago we had a series where 42% of our blunt liver injuries required surgery, 26% for hemodynamic instability and 16% for failed initial nonoperative management. The reasons that these patients initially managed nonoperatively failed were recurrent bleeding in one patient after eight hours of initial stabilization. That patient had an injury, a vena cava injury, and ultimately expired. The second patient continued to bleed and met our criteria for surgery after 24 hours of observation. And the third one developed right upper quadrant sepsis from devitalized liver tissue and required a completion right hepatectomy. And I was wondering, in Dr. Haller's patients with liver injuries, when in the course of their management were they operated on and for what reasons? I have a few questions for Dr. Haller. Was anything other than the CT scan used to evaluate these patients? In other words, have you totally abandoned peritoneal lavage, as we have. Were there any late complications of nonoperative management? You said you had no missed hollow visceral injuries. Were there any late bleeds or was there any sepsis? And how long do you keep the patient in the ICU? at bed rest in the hospital? at bed rest at home? on limited physical activities? and when do you allow them to return to PE class? And what is your protocol for follow-up? Do you follow them with CT scans, ultrasounds? How frequently do you follow them and what are your end points? Finally, you've addressed this personally, but what is the applicability of this method of management to adult patients? Is there something unique about the pediatric patient that makes this valuable? Lastly, I'd just like to echo the comment that Dr. Haller has already made. Nonoperative management does not mean non-surgical management. These patients must remain under the care of a surgeon and should not be delegated to our intensivist colleagues. And, finally, I think it's fair to say that it is not a sign of weakness to operate, in spite of what's printed in the literature. And that if a surgeon feels that a patient requires an operation, he should proceed with it.

DR. H. BIEMANN OTHERSON, JR. (Charleston, South Carolina): There is one area in which pediatric surgeons have been leaders, and especially people like Dr. Alex Haller, and that is in the management of blunt trauma. General surgeons are now accepting the fact that splenic salvage is safe and are beginning also to accept the fact that nonoperative therapy can be safe and successful. And that's occurring in the general surgical literature as far as hepatic injuries are concerned. We agree with Dr. Haller's protocol as outlined in his manuscript, and it's very strict. But I have two concerns. One is that it doesn't address the management or the detection of perforation of the gastrointestinal tract. We try in patients in whom we are going to manage with nonoperative measures, to introduce a contrast material into the stomach to outline the stomach and duodenum. Or course, that doesn't show the small bowel, but at least we would eliminate the gastric perforations. Do you advocate any such thing? And, second, obviously, you have different criteria for your pancreatic injuries because you operated on approximately half of those; whereas, the others had a much lower operative rate. What other criteria do you use for pancreatic injury, such as transection, etc.?

DR. DAVID V. FELICIANO (Atlanta, Georgia): As adult trauma surgeons have adopted a nonoperative approach with increasing enthusiasm, it is difficult to criticize the concept presented here. But it should be noted that nonoperative management in adults fails more often than in children because of the thinner capsule on the spleen and the liver, the higher incidence of associated GI injuries, and the higher incidence of associated chest wall and pelvic fractures in adults. Many adult trauma surgeons therefore follow very, very rigid protocols when practicing nonoperative management, including guidelines of what magnitude of injury is safe to watch, what amount of blood transfusion during observation is tolerable, and whether or not follow-up CT scanning is performed and at what intervals. This leads to my questions. You had a very clean separation in the manuscript in the presentation between patients undergoing early operation *versus* those managed nonoperatively. Is this really what happened or did some of your observed patients actually fall over into that operative group with a delayed operation the first 24 to 48 hours? Your protocol differs from that in other adult and pediatric centers, and I have a related question. What would you recommend in terms of tolerable blood transfusion in a child during the period of observation before proceeding to operation? I couldn't really find this information in the manuscript. Third, do you have any long-term follow-up from either your series, your previous series from Hopkins, or the National Pediatric Trauma Registry on the incidence of hepatitis C or hepatitis B in patients who are significantly transfused during a period of nonoperative management? Finally, in addition to Rick Rickett's question, how often do you CAT scan? In the adult trauma group, we CAT scan once in the hospital. And if these patients clearly show improvement, they are sent home with absolute bed rest for another week, with a family member in the house with them 24 hours a day. Is your protocol that rigid, and do you use CAT scanning until the injuries are completely healed?

DR. TIMOTHY C. FABIAN (Memphis, Tennessee): I'd like to ask three brief questions and then make a couple of comments. First, I would like to know if you use CT grading in Baltimore to evaluate liver and spleen injuries, and how does that impact on your management? The second one is along David's lines about transfusion requirements. What were your mean transfusion requirements in these patients? And given the data that was presented by Dr. Morris yesterday, I think all of us do need to be aware of hepatitis, especially there's always new brands of hepatitis coming out every couple of years. I don't really recall, although I'm not intimately familiar with pediatric literature, about the incidence of hepatitis developing in these patients, given the fact that they're going to live for a long time. Finally, would you please define the eight pancreatic injuries? How many of these are contusions? Because I have assumed that disrupted glands usually require surgery. A couple of comments: One, I'd like to correct Dr. Ricketts. He observed that they had four patients with multiple trauma undergoing operation; three were victims of child abuse and the fourth was a motorcycle accident. I would suggest that all four were victims of child abuse. Finally, I'd like to thank the authors for sending me this excellent manuscript. This isn't the standard. I'd like to thank them for sending it several days in advance. But, I really want to thank them for a different reason. Of 2887 trauma admissions, they had twelve undergo laparotomy. This is one in every 240 cases or basically one every three months. I assume that the house staff must have lined up at the operating room doors with baseball bats to fend off their colleagues when one went to surgery. So every time I hear our residents complain about taking care of nonoperative trauma in the future, I'm going to give them a copy of this paper.

DR. H. DAVID ROOT (San Antonio, Texas): I think it's important in the delineation of the natural history of this kind of injury. It's important, certainly for the pediatric surgeon. And I think it is most important because these standards are something that the non-pediatric surgeon is going to use and the pediatricians. As we go around the country looking at trauma centers, it's obvious that 95% or perhaps 98% of injured pediatric patients are managed by non-pediatric surgeons. And the pediatricians themselves are very covetous of the injured child, and they want to be involved with the management. So I think that we must not make it sound so easy that the pediatricians are going to demand management of these patients. And the emphasis of ongoing surgical intervention or observation is most important, because the pediatricians are very aggressive in this management protocol. What is your incidence of false positive and false negative CT scans? Do you have other evidence in the 25 nonoperated patients that indeed they had a splenic injury? Did they have ileus, drop in hematocrit, DPL, ultrasound, any other evidence? There is a significant incidence of false positive and false negatives. And, again, to reiterate the other question, at what level of hematocrit do you say "enough already," and intervene? And the incidence of the volume of transfusions I would also be interested in hearing. There is a little misleading statement, however, in your protocol, in that you said there are no deaths in the nonoperative managed group. But, after all, they all start out as nonoperative management, and that only those who were operated upon did have mortality. So I wouldn't make it sound quite that glowing, but it's a fine paper. I think it's a real contribution, and I think these guidelines must come from major institutions to guide the pediatricians who are going to get involved.

DR. J. ALEX HALLER, JR. (Closing Discussion): I want to thank all the discussants for bringing up some very important points that I did not have a chance to cover in my formal presentation. Let me try to address some of the specific questions. Dr. Smith pointed out that in the management of these children who are in shock there is a continuing danger that they might have secondary central nervous system injuries as a result of poor perfusion. And that, of course, is a continuing concern. That is one of the reasons we have tried to emphasize that if they are not hemodynamically stable after up to 40 cc per kilogram crystalloid replacement, then they need to go to the operating room. And I think I can say parenthetically and answer the questions about transfusions that we transfuse at that point. If the patient has received 40 cc per kilogram of crystalloid, is still hemodynamically unstable, they go to the operating room with blood hanging. And so rather than go by the hematocrit or go by any other hunch, if they need blood because of

their hemodynamic instability, unless there is another explanation, multiple open fractures, etc., but if this is due to the intra-abdominal injuries—and these are patients who predominantly had blood trauma to those solid organs,—the indication for going to the operating room and blood is hanging at that point. I don't know what the data are on hepatitis in children receiving transfusion. I asked Dr. Otherson if he had seen any such reports. I am simply not aware of the availability of that information, and, certainly, it is important. But that is not the reason that these children are initially managed without transfusion. It is, however, a plus if they can be managed nonoperatively. But all those who are operated upon receive blood. That was part of the decision to take them to the operating room. The pancreatic injuries have been questioned in terms of their management. The reason they were operated upon, aside from the fact that they had documented pancreatic injuries from their CT scans is because they remained hemodynamically unstable. We found the pancreatic injury in the course of their exploration. The two of them that had partial resection did have the tail transsected, and that was removed. The one patient, as you saw, did develop the pseudocyst which required drainage into the stomach a few days afterward. How long before these children were taken to the operating room? Usually within a few hours because they did not remain hemodynamically stable. There were only a few late operative procedures. The child that I showed you with the ruptured spleen was 6 hours following admission to the intensive care unit. And without having exact data, I would say all were within 12 hours following admission to the intensive care unit. Dr. Feliciano appropriately pointed out that there are different forces at work probably in the types of adult patients who are seen. Not only are they usually occupants in automobiles, but the high-velocity type injury as well as some of their physiologic responses do change our approaches to their management. Do we use CT grading? Yes, we do. We, however, have not used that as an indication for exploring, hoping that some of the higher-grade injuries could respond to nonoperative treatment. And your question about transfusion I have, I think, answered. The management of these patients, as Dr. Root appropriately points out, are not going to be always in children's centers by any means. And so all general surgeons must have the skills in their management because more children will be treated in regional general trauma centers than in those that are committed only to children. Finally, I would like to emphasize that in this group of patients, 12% required a laparostomy. In the National Trauma Center, 38% required laparostomy. That does not mean we don't operate more. I think what it does indicate is that many of those children in the National Registry are coming from different types of trauma centers, and so there may be different indications for exploration. But using this strict protocol, we have operated upon 12% of those with blunt abdominal injuries.