**Hypothesis:** Perihepatic packs used to control hemorrhage after liver injury increase the risk of complications and this risk increases the longer packs are left in place.

**Design:** Retrospective case series.

**Setting:** University level I trauma center.

**Patients:** Consecutive patients with hepatic injury.

**Main Outcome Measures:** Liver-related complications (biliary leak and abscess), rebleeding, and mortality.

**Results:** One hundred twenty-nine of 804 patients with liver injuries were treated with perihepatic packing. Of the 69 who survived more than 24 hours, 75% lived to hospital discharge. Mortality rates were 14% and 30% in patients with and without liver complications, respectively ($P = .23$). Liver complication rates were similar ($P = .83$) when packs were removed within 36 hours (early [33%]) or between 36 and 72 hours (late [29%]) after they were placed; the rebleeding rate was greater in the early group (21% vs 4%; $P < .001$).

**Conclusions:** Liver complications associated with perihepatic packing did not affect survival. Removing liver packs 36 to 72 hours after placement reduced the risk of rebleeding without increasing the risk of liver-related complications.

*Arch Surg.* 1999;134:958-963

**RESULTS**

**LIVER INJURY COHORT**

During the 9.5-year study period, 804 patients with liver injuries had a celiotomy. Perihepatic packs were used in 129 patients (16%). Most patients had suffered a blunt injury (68% and 59% in patients with and without packs, respectively; $P = .05$). When we compared patients...
PATIENTS AND METHODS

We performed a retrospective case study of 804 consecutive patients with liver injuries identified at celiotomy who had been operated on by the trauma service at the University of California, Davis, Medical Center from June 1, 1988, to January 1, 1997. Patients younger than 15 years and those who were declared dead on arrival were excluded from the study. We identified patients with liver injuries by reviewing the operative records of patients who had an exploratory celiotomy. We collected clinical information from both the Trauma Registry and from each patient's medical record.

We recorded the following information: age, sex, mechanism of injury (blunt vs penetrating), vital signs in the emergency department, operative procedure, intraoperative findings, length of operation, estimated blood loss, amount of blood transfused in the first 24 hours after injury, length of intensive care unit (ICU) and hospital stays, associated injuries, liver complications (such as bilaoma, persistent bile leak, and hepatic or subphrenic abscess), time to pack removal, and incidence of rebleeding. Complications and rebleeding were defined as follows. Biloma indicated an intra-abdominal collection of bile that required percutaneous or operative drainage; persistent bile leak indicated a bile fistula that drained longer than 10 days; intra-abdominal or liver abscess indicated a culture-positive right subphrenic or hepatic fluid collection that required drainage; and rebleeding indicated a liver hemorrhage that required replacement of perihepatic packs. Overall severity of injury was measured using the Injury Severity Score (ISS)\(^\text{13}\) and predicted survival was determined using the TRISS\(^\text{14}\) methodology and the 24-hour ICU Score.\(^\text{15}\) Hypotension in the emergency department was defined as a blood pressure of 90 mm Hg or less. Liver injuries were graded retrospectively based on the description found in the operative report using the scale developed by the Organ Injury Scaling Committee of the American Association for the Surgery of Trauma.\(^\text{16}\)

The decision to use perihepatic packs was made by the attending trauma surgeon on a case-by-case basis. In general, we opt to pack liver injuries in patients with hepatic hemorrhage that persists after arterial bleeders have been controlled by direct suture ligation. Gauze laparotomy sponges were used to pack liver injuries in all patients treated with perihepatic packing. Perihepatic packs were removed once the patient's hypothermia, acidosis, and coagulopathy had resolved and the attending surgeon felt the patient was ready to return to the operating room. All patients had their packs removed between 24 and 72 hours after injury. If uncontrollable hemorrhage was encountered at the time of pack removal, perihepatic packs were replaced and removed at a subsequent operation.

Statistical analysis was performed using the SYSTAT 8.0 software (SPSS Inc, Chicago, Ill). Continuous variables were compared using 2-sample \(t\) tests, and discrete variables were compared using either the Fisher exact or Yates corrected \(\chi^2\) tests, as appropriate.

whose liver injuries were managed without packs with those who had their liver injuries packed, we found the packed group had a higher mean \(\pm\) SD ISS (29 \(\pm\) 15 vs 21 \(\pm\) 14; \(P<.001,\)) were more likely to be hypotensive on presentation (52\% vs 23\%; \(P<.001\)), had a higher-grade liver injury (4.2 \(\pm\) 0.8 vs 1.7 \(\pm\) 0.8; \(P<.001\)), had a larger intraoperative blood loss (4.1 \(\pm\) 4.1 vs 1.0 \(\pm\) 2.4 L; \(P<.001\)), and had a higher mortality rate (60\% vs 15\%; \(P<.001\)). Eighty percent of the patients with perihepatic packs had grade IV or V injuries compared with the patients managed without packs, 89\% of whom had a grade III liver injury (Table 1). Patients who had their injuries packed and the group managed without packs were similar with respect to age (35 \(\pm\) 14 vs 35 \(\pm\) 15 years, respectively; \(P=.92\), sex (72\% vs 79\% male, respectively; \(P=.36\), and mechanism of injury (69\% vs 56\% blunt, respectively; \(P=.07\)). Although length of hospital stay was similar for the 2 groups, outcome with respect to mortality favored patients who were managed without liver packs (Table 2).

Table 1. Distribution of Liver Injury Grades for Patients With Liver Injuries Identified During Celiotomy for Patients Managed With Perihepatic Packs vs Those Managed Without Perihepatic Packs

<table>
<thead>
<tr>
<th>Liver Injury Grade</th>
<th>Packed ((n = 123))</th>
<th>Not Packed ((n = 642))</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0 (0)</td>
<td>310 (48.3)</td>
</tr>
<tr>
<td>II</td>
<td>0 (0)</td>
<td>251 (39.1)</td>
</tr>
<tr>
<td>III</td>
<td>24 (19.5)</td>
<td>72 (11.1)</td>
</tr>
<tr>
<td>IV</td>
<td>50 (40.7)</td>
<td>6 (1)</td>
</tr>
<tr>
<td>V</td>
<td>48 (39)</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>VI</td>
<td>1 (0.8)</td>
<td>2 (0.3)</td>
</tr>
</tbody>
</table>

LIVER PACKING GROUP

Perihepatic packs were used in 129 (16\%) of the 804 patients; 35 of the 129 died in the operating room, an additional 25 patients died within 24 hours after injury, and 14 died later in their hospital course. Overall survival was...
43% compared with a TRISS-predicted survival rate of 31%. Intraoperative deaths and deaths occurring within the first 24 hours after injury were due to irreversible disseminated intravascular coagulation or to severe head injury. These patients were excluded from further analysis.

Sixty-nine patients survived the initial operation and lived longer than 24 hours after injury. The predicted survival rates based on the TRISS method and the 24-hour ICU Score were 47% and 56%, respectively. The actual survival rate for these 69 patients was 75%.

In analyzing the 69 patients who survived at least 24 hours after injury, we found survivors and nonsurvivors to have similar characteristics (age, ISS, sex, mechanism of injury, grade of liver injury) with the exception that nonsurvivors were more likely to be hypotensive on presentation (53% vs 21%; P = .03) and required more blood transfusions in the first 24 hours after injury (20 ± 12 vs 12 ± 11 packed red blood cell units; P = .008). The liver complication rates were similar in the 2 groups, with 19 of 52 survivors and 3 of 17 nonsurvivors developing an intra-abdominal abscess or biliary leak (P = .25).

Twenty-two patients developed liver-related complications. In comparing patients who developed liver-related complications with those who did not, we found their ISS was similar (25 ± 10 vs 27 ± 14, respectively; P = .53), their liver injury grade score was similar (4.1 ± 0.7 vs 3.9 ± 0.8, respectively; P = .56), and their intraoperative blood loss was similar (3.3 ± 3.4 vs 3.1 ± 3.0 L, respectively; P = .81). Patients who developed liver-related complications had longer hospital courses than those who did not (45 ± 33 vs 17 ± 16 days, respectively; P = .001); however, mortality rates were similar in the 2 groups (14% vs 30%, respectively; P = .23).

<table>
<thead>
<tr>
<th>Timing of Perihepatic Packing Removal</th>
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All patients had their packs removed between 24 and 72 hours after they were placed. Infection rates and rebleeding complications were similar when patients had their packs removed within 36 hours were compared with those who had their packs removed between 36 and 72 hours after the initial packing. We hypothesized that leaving the packs in longer would increase the incidence of liver-related complications. However, when we compared patients who had their packs removed within 36 hours after they were placed with those who had their packs removed 36 to 72 hours later, we found the liver-related complication rates to be similar (Table 3).

In comparing the 39 patients who had their packs removed within 36 hours (early) with those who had their packs removed 36 to 72 hours after they were placed (late), we found the 2 groups to be similar in age (31 ± 12 vs 33 ± 10 years, respectively; P = .53), mechanism of injury (56% vs 83% blunt injury, respectively; P = .15), presenting hypotensive (23% vs 33%, respectively; P = .20), ISS (25 ± 10 vs 25 ± 14, respectively; P = .96), liver injury grade (3.9 ± 0.7 vs 4.0 ± 0.8, respectively; P = .78), intraoperative blood loss (3.0 ± 2.3 vs 3.6 ± 4.3 L, respectively; P = .45), and amount of blood transfused in the first 24 hours after injury (14 ± 13 vs 13 ± 15 packed red blood cell units, respectively; P = .99).

Despite the similarity in the number of liver-related complications in the 2 groups, the rate of recurrent liver hemorrhage requiring repacking was markedly higher in the group of patients who had their packs removed early (Table 3). Morbidity as measured by length of stay (hospital and ICU) and mortality rates were similar in the 2 groups (Table 3). Liver packs were successfully removed 2 days after they were replaced in patients who required repacking due to recurrent liver hemorrhage.

**Comment**

Even with the move to nonoperative management of liver injuries, we still encounter a subset of patients who require operative intervention to control liver hemorrhage. In fact, exsanguination from major liver injury is the most common cause of intraoperative death. Some patients with liver injuries will have continued hemorrhage even after direct ligation of bleeding vessels. Many of these patients have a coagulopathy and are acidotic and hypothermic. These patients benefit from a “damage control” strategy and from restoration of homeostasis in an ICU. Perihepatic packing can be used to tamponade and control hepatic hemorrhage and abbreviate the operation.

Our goal was to determine if perihepatic packs increase the risk of intra-abdominal abscesses and bile leaks after major liver injuries, and to determine if the risk of liver-related complications increases the longer packs are left in place.

Our findings support but do not prove the contention that perihepatic packing is a useful strategy in managing major liver injuries. Overall survival for the group of patients whose liver injuries were packed, including...
those who died in the operating room while an attempt was being made to pack their injuries, compares favorably with the TRISS-predicted survival for these patients. The difference between predicted survival (calculated using both the TRISS and 24-hour ICU Score methods) and actual survival rates was even more dramatic when we excluded patients who died in the operating room or the ICU within 24 hours after injury. Although comparisons of actual mortality rates with predicted mortality rates (TRISS or 24-hour ICU Score) cannot be used to establish the validity of a treatment strategy, it is reassuring to know that patients who had their liver injuries packed did not have a higher than predicted mortality.

The mortality rates for both patients who had their injuries packed and those who did not were high. Their mortality rates are consistent with the severity of injury encountered in this select group of patients. By excluding patients who had liver injuries managed nonoperatively, we eliminated patients with less severe injuries and many of those with severe yet isolated liver injuries.

To identify a more equivalent group of patients to compare with the group of patients who had their liver injuries packed, we narrowed our comparison to include only patients with a liver injury grade of III or more. Not surprisingly, patients who had their liver injuries packed were more severely injured and therefore had a higher mortality rate; however, we were surprised to find that the liver-related complication rates were similar in patients managed with or without liver packs. This probably represents a statistical aberrancy because many patients in the group treated with perihepatic packing died early after injury and do not have the opportunity to develop complications. Thus, the findings suggest that patients managed with perihepatic packing have a higher rate of liver-related complications; however, because patients managed with liver packs had more severe injuries and a worse physiologic status on presentation, it is not clear whether the higher complication rate should be attributed to the packs, the more severe injuries, or a combination of the two.

Patients who developed liver-related complications had a longer hospital course; however, patients who developed liver complications did not have a higher mortality rate than those who did not develop complications.

Many surgeons recommend that liver packs be removed as quickly as possible to reduce the rate of infectious complications.7,12,21-23 Our findings support previously made recommendations that the timing of pack removal is not as critical as reversing the detrimental effects of severe hemorrhagic shock and that the packs should be removed after “hemodynamic stability” is achieved.9,11,24 Based on our findings that the incidence of rebleeding was significantly greater in patients whose packs were removed within 36 hours, we recommend that the packs be removed between 36 and 72 hours after injury. When packs were removed more than 36 hours after injury, the rebleeding rate was low and the liver complication rate was similar to that of patients who had their packs removed within 36 hours of injury.

Perihepatic packing and “damage control” laparotomy can be lifesaving in patients who require urgent laparotomy because of persistent hypotension due to a major liver injury. Perihepatic packing seems to be associated with an increased risk of liver-related complications such as subphrenic or hepatic abscesses, bilomas, and bile fistulas; however, in our experience these complications were not overwhelming and were not associated with an increase in mortality. We recommend using perihepatic packing in patients with major liver injuries, especially in patients who are acidic, coagulopathic, and hypothermic. The packs should be removed 36 to 72 hours after being placed.

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CONCLUSIONS

REFERENCES


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Ronald V. Maier, MD, Seattle, Wash: This is an important paper by Dr Caruso and his colleagues dealing with a very important problem and a very frustrating problem. We have improved outcomes from severe injury, particularly multiple system injury, dramatically over the last 3 to 4 decades. However, exsanguination from severe hepatic injury continues to frustrate us and it is one of the few very few injuries that still has a high mortality due to uncontrollable exsanguination. As stated by the authors, we have now come full cycle in our approach to this injury. At the turn of the century, packing was adopted as lifesaving but had an excessive list of complications, primarily infectious, because the packs were left in place for 1 to 2 weeks to ensure hemostasis; other approaches such as advanced ligature techniques were not available to the surgeon at that time. As surgical techniques improved, perioperative support advanced, and blood banking with component therapy for coagulopathy and other issues developed, the approaches developed for elective hepatic resection were then adopted for the treatment of the injured liver. Major hepatic resections became the norm for the injured liver. But as trauma systems improved and patients with increasingly severe liver injury survived to reach the OR, the surgeon is faced with injuries that could not be definitively treated as in the elective setting. There was not excellent hemostasis, and patients with massive blood loss or other systemic injuries would rapidly became hypothermic and coagulopathic, and subsequently acidotic and die of their ongoing blood loss. Recently, identification of the patient with high-risk hepatic injury at high risk for hypothermia and coagulopathy early in the procedure has enabled us to control the predominantly venous bleeding by packing and to use full ICU support and subsequent “early” removal to prevent complications that had been identified in the past. While unproven by any prospective randomized trial, those who frequently encounter these challenging cases rapidly adopted this “new” technique of early packing, which of course was not new but just a reiteration of a century-old approach. The focus is to avoid entering the vicious spiral that leads to the death of these patients.

It is unfortunate that we are using a technique that has never been studied in a prospective, randomized trial with matched cohorts to prove that it is the most effective approach. Similarly, in this study, this same assumption based on no hard data was undertaken by these authors with no attempt to test whether the packing is beneficial compared with definitive repair or resection. As I mentioned, this is unfortunate, since looking at the numbers, one might not be impressed. The mortality in the packed group was 60% compared with 7% in the nonpacking group. If one were to present that to the local HMO, one would quickly see which approach would be preferred. Even when the authors limited the analysis to grade III-VI severity injuries, the mortality was 3 times higher in the packed group in these similarly injured livers. Of course, as we frequently argue in such issues, packing must have been done in the more severely injured patients. The authors have somewhat documented this by using injury stratification such as ISS, blood loss, and hypotension. Yet we are still missing a true matched cohort to prove we have made the right assumption. The authors state they did this study to reinforce the concept of packing as a valid concept, but do they have any truly matched cohort data to prove the concept is correct?

For those patients who survived at least 24 hours, the mortality was only 25%. I looked at a similar 3-year population at Harborview Medical Center in Seattle, Wash, and we had very similar results with a 22% mortality in those who survived 24 hours. But, an important issue is what of those who died during the first 24 hours? Those who died of irreversible DIC? Early packing is meant to avoid irreversible DIC. How many of the 60 patients they excluded who died early died of DIC? Could DIC have been prevented and could the patients have been saved if packing had occurred earlier in the operation? Was there too much delay during the operation due to intraoperative attempts to definitively treat the injuries? Do the authors have any data on the timing of packing during the case? I constantly reinforce to residents that they need to make the diagnosis, identify the severity of injuries, and start packing within 5 to 10 minutes of opening the abdomen to be most effective. Do the authors have any data as to whether packing earlier in the course of the operation was more effective than starting later when the patient was already becoming coagulopathic, particularly since they had a significant number of patients die of their irreversible DIC postoperatively and bleeding intraoperatively?

However, the main goal of the study was to determine if timing of pack removal affected the rate of rebleeding and the incidence of postoperative complications such as biloma, bile leak, and abscesses. The authors demonstrate that rebleeding occurred more frequently, 21% vs 4% in the early removal group. This is what one would expect. The overall importance of complications was confirmed in that while there was no effect on mortality, there was a significant increase in length of stay, 43 days with complications vs 17 days without. This avoidance of complications is important. They noted that there was no difference in complications between packs removed early (<36 hours) than late (36-72 hours). This removal at 36 to 72 hours appears to be safest with no increase in complications. Unfortunately the numbers of patients become very small in this final analysis, 39 patients vs 24. While I believe the results, the risk of a β error is significant and I wondered if the authors could comment on this potential problem.

In addition, because of our fear of reproducing the complications of late pack removal, we have adopted a very conservative approach in these patients to the point of almost rushing the patient back emergently to the OR to remove the packs. When one says early, does one mean less than 12 hours or 24 hours? Does one mean a reasonable 36 to 72 hours as the authors propose? The “36- to 72-hour group” would argue is not an extended removal but still early removal. Thus the authors in this study have aided us greatly in making a rational timing decision for reoperation. What is not addressed is what is the safe limit at the far end? We at Harborview have noted that there is a noninfectious systemic toxicity or systemic inflammatory response that appears to occur after 3 to 4 days in response to these retained sponges as foreign bodies in the peritoneal cavity. Even though they are not infected, the patients appear to be at risk for this systemic toxicity and damage to other organs such as the lung and liver itself. Do the authors have any data on how long is safe? Should we go longer than 3 days to further ensure hemostasis and sealing of the liver parenchyma? When do infectious and other complications be-
gin? When do we fall into the trap of truly reinventing the wheel and leaving them in too long?

**Steven N. Parks, MD, Fresno, Calif:** How do you determine the time to bring the patient back to remove the packs? We have tried to correct the coagulopathy, be sure there is no acidosis, and make sure there is no more hypothermia before we bring them back to remove the packs. I have tried to remove the packs at 36 to 48 hours, not going as long as 72, if possible. One of the reasons for taking the packs out earlier is because they smell bad at 72 hours, but I don’t disagree that they should be left in until the appropriate time. Would you tell us what the appropriate time is?

**Demetrios Demetriades, MD, Los Angeles, Calif:** Most importantly this paper agrees with my biases and principles. I do believe that the greatest advancement in liver injuries in the last 10 years is the very early packing. In my opinion a good experienced trauma surgeon will do a quick evaluation and within minutes should pack and come out. At our center the patient will go from the OR to the angiography suite. Do the authors have any experience with that?

**Charles Scudamore, MD, Vancouver, British Columbia:** I was interested in the authors’ experience with their bile fistula. We have been able to avoid operating on significant bile fistulae just by sphincterotomy and/or stenting the bile duct. They all close spontaneously. I wondered if the authors have bile fistulae just by sphincterotomy and/or stenting the bile duct.

**John Mayberry, MD, Portland, Ore:** It is important that we keep discussing this even though it is well established in our practices. I wonder if the authors stratified their patients according to the Abdominal Trauma Index or other abdominal injury such as bowel injury in regards to the development of abscess and other complications. What were the causes of death?

**Thomas Berne, MD, Los Angeles:** I have 2 questions. When you said “rebleed,” it sounded like you meant that the rebleeding occurred as you were removing the pack. Was it just “rebleeding” between at some other time? The other question is did hollow viscus injury affect the timing of the removal of packs?

**Wilton A. Doane, MD, Santa Barbara, Calif:** According to the record, mortality was higher in patients who did not develop complications. That seems a little puzzling.

**Dr Battistella:** As usual, Dr Maier, you hit the nail on the head with all of your comments. I will take your questions a little bit out of order because it will allow me to address some of the issues simultaneously.

First of all you pointed out correctly that we did not show that the perihepatic packing technique is any better than any other technique with respect to controlling hemorrhage. That was not the goal of our study. We were as disturbed as you are by the fact that we still have a high rate of persistent uncontrollable bleeding, both in the operating room and postoperatively, with this technique. We had 35 patients who died in the operating room. All of those died of uncontrolled DIC. Many of the patients presented moribund. Some presented with no blood pressure, a few had ER thoracotomies, etc, etc. Many were the type of patient who would be very difficult to save under the best of circumstances. But, nonetheless, we are not convinced that perihepatic packing is the end-all treatment for all liver injuries and, in fact, it may be that some combination of packing and hepatic artery ligation or, as Dr Demetriades pointed out, maybe packing and prompt angiography to embolize specific bleeders may be the best treatment option in patients who do not respond to liver packing.

As we looked at the patients with respect to the decision to pack them, all patients who were packed had the decision made early in their course. The total operative time for all patients regardless of how you analyze them, whether they were packed and survived or were packed and developed complications, was about 90 minutes. That represents the time the patient spent in the operating room (from entering and leaving the operating room). I can’t tell you how quickly the decision to pack the patient was made, but I can tell you that the total amount of time the patients spent in the operating room was fairly short.

The second issue that you raised is whether our study suffers from a &egrave; error with respect to the timing of pack removal. All I can tell you is that our series is a fairly large series as compared with others that are reported in the literature. The point I am trying to make is that liver injuries that require packing are rare and in order to get an answer to that question that won’t be subject to a &egrave; error we will require a prospective multicenter trial. Over a 10-year period we were able to accumulate an experience with 69 patients in an institution that is fairly busy. If you look at some of the other series, the Feliciano series, the Cogbill series, etc, etc, their numbers are pretty similar. Some of those are multicenter series. Therefore, in order to avoid a type II error, we have to organize a much larger patient base.

Dr Parks, you asked about the timing of pack removal. It goes without saying and I apologize if we didn’t emphasize this point, but aggressive efforts are made to resolve the patient’s hypothermia, acidosis, and coagulopathy before removing the packs. Then the next question is when the patient is looking good and the hypothermia, acidosis, and coagulopathy are resolved, do you need to wait any longer? In some of our patients, we obviously didn’t and the conclusion that we draw from our experience is that you probably should until 36 to 72 hours after the packs were placed to allow the clot to mature.

Dr Berne asked the question about the rebleeding and how we defined that. Rebleeding was defined as those patients who had to be repacked at the time that an attempt was made to remove the packs because of recurrent uncontrollable hemorrhage.

**Dr Demetriades** asked about the use of angiography. I addressed that question in part already, but let me go on to say that we have not taken full advantage of our interventional radiologists when dealing with severe liver injury. We utilize angiography in those patients who have evidence of continued bleeding after they are packed. We do not routinely angiography all patients who have been packed. Maybe an approach that utilizes angiography in all patients with liver injuries that require packing might avoid delays in those patients who do have continued arterial bleeding. So we take your suggestion not lightheartedly.

**Dr Scudamore** asked about bile fistulae. We have a limited experience with stenting the common bile duct in patients with persistent bile leaks. I do think that it makes a difference. We didn’t address that in this paper, but I can tell you from my experience with anecdotal cases that patients who had prolonged bile fistulae resolved very quickly once their duct was stented. I do think that stenting the common bile duct in those patients is effective in resolving the bile leak.

**Dr Mayberry** asked if we stratify patients according to their Abdominal Trauma Index score. We did not and we probably should have. I think that also addresses Dr Berne’s question regarding concomitant bowel injuries. We did not specifically address the associated hollow viscus injury, nor did we specifically address the Abdominal Trauma Index.

**Dr Doane**, you asked about the fact that we had a higher mortality rate in the group of patients who did not develop complications. I think this has a simple explanation. As you recall, most of the deaths occur early in the process and those patients really don’t have an opportunity to develop complications. There is no survival advantage if you develop a complication.