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DISCUSSION

DR. J. DAVID RICHARDSON (Louisville, Kentucky): This paper represents another excellent contribution and presentation from the Houston group on the management of a difficult topic in trauma, and I certainly would recommend the manuscript by Drs. Feliciano, Burch, and Mattox to your attention. They have done an excellent job of outlining some of the real pitfalls that these patients present.

At issue is whether or not the atriocaval shunt is really necessary for juxtahepatic caval injuries or whether these injuries really could be repaired with similar results without the use of a shunt. With the use of an atriocaval shunt, we have treated 24 patients with retrohepatic or juxtahepatic caval injuries at the University of Louisville. Unlike the Houston group, 16 of our cases were due to blunt trauma, and only six were due to penetrating trauma.

Seven of these 24 patients were able to leave the operating suite alive. Three subsequently died of sepsis, coagulopathy or various other problems, and there were four long-term survivors. These results are not altogether dissimilar from those presented from Houston. Two of the four survivors had blunt trauma unlike the Houston group's series and two of our patients had penetrating injuries. In two of these cases in which I personally participated, the caval injuries were fairly small, and quite honestly, they could possibly have been repaired by direct suture technique or conventional techniques without the use of a shunt. However, I agree with the point the authors made, that is, once these injuries are recognized, you need to commit fairly promptly to either using the shunt or not, and we did choose that technique with success.

We have come to believe that prompt placement of the shunt, as has been indicated by the authors, before the development of coagulopathy is the key to its successful use, and, therefore, we try to move forward with prompt shunt placement as soon as we recognize the severely bleeding venous injury in the retrohepatic position that does not promptly respond to a Pringle maneuver.

Technically, we have found the endotracheal tube to be useful in that it obviates the need to encircle the inferior vena cava with its attendant technical complications. I think it is maybe a little bit tougher to cut that more proximal hole, but at least you don't have to deal with the distal cava in quite the same manner.

In our residency program, we have made liberal use of the fresh dissection lab which we developed in conjunction with the department of anatomy, and I think, quite simply, if you are going to try to teach residents to do that, you really can't do it with a bleeding, dying patient, and that the forethought of having gone through this a couple of times in the dissection lab is certainly one that I would commend to those of you who are involved in resident education or who might be an occasional operator in this area yourself.

In summary, we believe that the atriocaval shunt does have a place in these most difficult injuries, but that the very nature of the injuries themselves will always make the survival ability of these patients lower

than would ordinarily be satisfactory. We will continue to use the shunt in these selected patients, however.

DR. LEON PACTER (New York, New York): I would like to congratulate the Baylor group on their superb contribution to the management of juxta hepatic venous injuries employing an atriocaval shunt.

A recent review of 66 cases treated at major trauma centers in which atriocaval shunts were used revealed that only 15 patients survived for a mortality of 77%.

The authors were able to salvage 6 of 18 patients for a mortality of 67%, when patients with resuscitative thoracotomy were excluded. The lethal nature of this injury is quite evident.

Why has the mortality with atriocaval shunting been so high? First and foremost is the devastating nature of the injury itself, but in most series, failure of the atriocaval shunt was probably related to three key factors. First, delay in early recognition of the injury. Second, delay in shunt-insertion until all other methods have been exhausted to control hemorrhage. At this point, a coagulopathy exists and no matter what the surgeon does, the patient will most probably die. To insert a shunt at this time only will result in a bad name for the procedure. Three, lack of experienced personnel for expeditious shunt insertion. If these three factors are avoided as they were by the authors, then the devastating nature of the injury itself must be implicated as the eventual cause of death.

Given this fact, what then is the optimal method of managing these injuries? Atriocaval shunting no doubt will be the method of choice, but alternatives do exist.

We managed six consecutive patients at Bellevue Hospital without a shunt, employing the technique of prolonged portal triad occlusion up to 60 minutes and rapid finger fracture of normal hepatic parenchyma to get down to the site of vascular injury for primary repair. Five patients survived.

Clearly, there exists a group of patients that can be managed without a shunt.

In their manuscript, the authors themselves report 15 patients with retrohepatic caval injuries who were managed without a shunt. Seven of the 15 survived for a salvage rate of nearly 50%. The survival in this group of patients without a shunt is clearly somewhat better than the 67% reported in patients in whom a shunt was used.

I would appreciate the authors' commenting on the two groups and elucidating for us the criteria for either using an atriocaval shunt or not.

As no one institution has enough patients for statistically significant data, a larger series will be needed to set up guidelines as to which patients require a shunt and which patient can be managed without it.

I enjoyed the manuscript, and I am sure that it will be a landmark paper in the field of hepatic trauma.

DR. JOHN OCHSNER (New Orleans, Louisiana): Dr. Feliciano has shown us that this is really a devastating lesion, having an 81% mortality.

When I was a boy some 30 years ago in Houston, we researched our inferior vena cava injuries, and we had 48 inferior vena cava injuries. There were four patients with retrohepatic vena cava injuries. All four patients died, but two of them were not bleeding actively at the time of exploratory surgery, and it wasn't until we entered the hematoma that we got into the bleeding problem.

We suggested at that time that these areas be packed in an attempt to test this clot and to maintain an intact retroperitoneal space. In order to test this hypothesis, we went to the lab.

(Slide) We took a Himelstein valvulotome, inserted it through the common femoral vein of a dog, brought it up into the retroperitoneal space at the level above the renal veins, and this cut out an elliptical piece of vein and adjacent tissue. The instrument cuts out a section in the posterior aspect, leaving the peritoneum intact. (Slide) You can see the hemorrhage begin.

(Slide) Shortly thereafter, you see this massive hemorrhage. We did six dogs in this group. All of them survived. Then we sacrificed them a week later.

(Slide) And this is what you see: most of the blood has been absorbed. We opened the retroperitoneal space. (Slide) And one can see this elliptical incision of the vena cava that allowed the hemorrhage and yet allowed the clotting with the intact retroperitoneal space.

We then took another series of dogs to test whether we could make an incision into the inferior vena cava and then just make the retroperitoneal space intact. We did this by putting some buttress stitches as one sees here, taking a knife, a 15 blade, and incising the retroperitoneum and inferior vena cava. These buttress stitches are not into the cava but just into the peritoneum, and yet the retroperitoneum space controls the bleeding. Next, the dog is a sacrifice (Slide) a week later, showing a relatively small incision compared to the one in which a piece of tissue is taken with the valvulotome.

So we have pretty well proved that if one has an intact retroperitoneal space, with the low pressure in the hepatic veins and inferior vena cava at this level, one need not worry about the continued bleeding.

Now, since there was no evidence of duodenal injuries which would have required opening the retroperitoneal space I would like to ask the authors whether although there was a significant amount of concomitant injuries, could their patient have possibly been treated by allowing the retroperitoneal space to be maintained as an intact space?

Today with the advent of biological glue where we are able to control probably many of lacerations in the liver, I wonder if, in retrospect, Dr. Feliciano thought any of his patients could have been treated by a more conservative method of controlling the hemorrhage with tamponade.

DR. JOHN D. ASHMORE, JR. (Greenville, South Carolina): (Slide) That is a venacavogram made 6 weeks after a 23-year-old came in after turning his dune buggy over while racing.

As we opened the abdomen, it was obvious we had a serious hepatic injury, so without touching it, we went to a right thoraco-abdominal. He had avulsion of the retrohepatic cava, so we occluded above and below with clamps, and also used aortic occlusion at the diaphragm.

By the time we got through, we ended up putting in a 20 mm Dacron graft. It is about 4 cm long.

He, of course, had a rocky post-op course, but was discharged after about 4 weeks, and I had occasion to do a follow-up on him this summer.

He was admitted with a fractured pelvis. He was racing his speedboat and the throttle stuck. He said he had done 130 miles an hour, but down-home people tend to exaggerate. He, at least, fractured his pelvis when he did bail out of the boat.

I present this because there is still some question about Dacron grafts in the vena cava, and I did this cavogram in 6 weeks because in a series of dogs, just about all the grafts had some thrombi, and complete occlusion at 6 months. I was questioning whether or not he should be on chronic anti-coagulation. We did not anti-coagulate him, and as I say, he is still around 9 years later.

DR. ALFRED GERVIN (Richmond, Virginia): May I first congratulate Dr. Feliciano on his very nice presentation and thank him for providing me in advance with a copy of the 35-page manuscript.

The injury that the authors address, perforation of the retrohepatic

portion of the IVC, is truly a dreaded situation in trauma, often leading to the demise of the patient and to the graying of the hair of even the most experienced trauma surgeon.

All surgeons have had some experience with this particular traumatic process, and I am delighted that we have before us today a rather extensive experience for review.

In this series from, the Ben Taub Hospital, there were 31 patients. Of all 31 patients, 11 were in full code arrest at the time of presentation to the emergency department and underwent the emergency department thoracotomy. All died.

Of the remaining 18 patients, six survived. If we closely scrutinize these survivors, several characteristics are evident. Number one, all had penetrating trauma.

At our institution we are one for twelve with caval shunting for patients with blunt trauma.

Number two, over one-half of your survivors were not in shock when they arrived in your emergency department. Therefore, these patients were in fairly good medical condition.

Number three, more than 70% of your patients had injuries only of the cava and not of the hepatic veins—perhaps a much less difficult injury to handle.

And four, no patient in your series with concomitant hepatic injury survived.

These data, therefore, motivate three questions.

Based on your experience (number one) should shunting even be attempted in patients who have undergone emergency room thoracotomy? Your mortality was 100%.

Number two, should shunting even be attempted in patients with concomitant major hepatic injury? Again, your mortality was 100%.

Number three, for these patients might not extensive abdominal packing provide a better chance for survival?

DR. ARTHUR J. DONOVAN (Los Angeles, California): Dr. Feliciano and his associates have importantly focused on the major unresolved problem and cause of mortality in hepatic trauma: hepatic vein and juxtahepatic venous injury. A number of years ago, we reported eight cases of such injury treated with a variety of techniques of vascular isolation: atrial shunt, infrarenal shunt, and multiple vascular occlusions as described by Heaney (*i.e.*, occlusion of the vena cava above and below the liver, a Pringle maneuver, and occlusion of the supracolic aorta with a clamp or compression device). Four of the eight patients survived. Based on this clinical experience and the results of subsequent canine experiments, we concluded that multiple occlusive clamps were the preferable technique. We continue to believe that if vascular isolation is necessary, multiple occlusive clamps are the simpler technique and create a field that is dry enough for vascular repair. Aortic occlusion above the celiac axis is essential to prevent infradiaphragmatic flow when the suprahepatic cava is occluded.

Among 234 cases of hepatic trauma treated in the past 2 years, vascular isolation by multiple occlusive clamps was employed in four cases. This rate of vascular isolation is generally comparable to that reported by Dr. Feliciano. There were two survivors, one of whom underwent major hepatic resection. Despite resurgence of interest in packing, we are not convinced that it is effective in cases of the most severe hepatic vein and juxtahepatic venous injury. In closing, I would ask Dr. Feliciano to comment on whether he has utilized the technique of multiple occlusive clamps and on his experience with packing for major venous injuries. I fear that the nature of major hepatic vein and juxtahepatic venous injury is such that with currently available techniques, a continued high mortality will be experienced.

DR. JON M. BURCH (Closing discussion): Dr. Richardson, we have used the endotracheal tube in only a single case in this series. However, it does eliminate having to gain vascular control of the suprarenal vena cava, which, according to our experience, was a major source of technical difficulty. Avoiding this step may help improve results in the future.

We have also taken our residents to the dog lab and rehearsed the use of the shunt with them. I think that is an excellent suggestion for those of us with these facilities.

Dr. Pachter asked about the seven survivors with retrohepatic vena cava injuries who were mentioned in the study but in whom shunts

were not used. In general, these patients had smaller injuries which usually could be occluded with a finger, were not as sick on admission, and did not require resuscitative thoracotomy with the frequency that those in our shunt series did. I am quite certain these are the reasons that those patients survived. It is also possible that the shunt might have benefited some of the patients in whom it was not used.

I agree completely with Dr. Ochsner's comments. Nonexpanding retrohepatic hematomas with an intact retroperitoneum ought to be considered similar to hematomas caused by blunt trauma to the kidney or pelvic bones, all of which are best left alone.

The senior author of this paper has venocavograms of two patients with penetrating injuries that show retrohepatic venous defects. One of these patients was not operated on and the other closed promptly after finding a small retrohepatic hematoma. Both patients survived.

Dr. Ashmore, we have not had to use a graft in the last 270 patients with vena caval injuries, but it is reassuring to see that patients can do well over a long period of time if such a graft is required.

Dr. Gervin, based on our experience, it is difficult to justify the use of a shunt in the circumstances you mentioned. However, this is a small

series, and these injuries are always going to be rare. We have always operated under the supposition that unless we try to save such desperately ill patients, we will never succeed. Furthermore, for the individual patient who survives such an exotic injury, the survival rate is 100%. Therefore, we will persist in trying to use these techniques, including EC thoracotomy.

Packing is not an alternative to suture repair of large venous injuries. Our results, when that has been attempted, have been poor. These injuries must be repaired. Packing may be useful as an adjunct in patients who have coagulopathy, and was used successfully in one of the patients that Dr. Feliciano mentioned.

Dr. Donovan, I still marvel at the paper that you and Dr. Yellin wrote in 1971. We have tried the caval clamping technique which you have described. Our patients have not tolerated this procedure well. We have had the experience of trying this initially, with the patient experiencing cardiac arrhythmias and profound hypotension and having an unsuccessful outcome. Certainly there are patients who will tolerate this procedure, but we just don't know how to pick them, and that has been a source of great frustration.