Lessons Learned in Adopting Endovascular Techniques for Treating Abdominal Aortic Aneurysm

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Hypothesis: Endovascular exclusion of abdominal aortic and common iliac aneurysms can be performed safely, and in the short term represents a feasible alternative to traditional, open aneurysm repair.

Patients and Methods: Forty-one patients were treated with endovascular grafts for 39 abdominal aortic and 2 common iliac artery aneurysms.

Results: All devices were successfully deployed. The size of the abdominal aortic aneurysms varied from 4.9 to 11.9 cm (average, 6.13 cm). The median procedure time was 195 minutes. There was one iliac artery rupture, which required celiotomy for repair. The hospital stay varied from 2 to 39 days (average, 6.7 days). The perioperative mortality rate was 2.4%. Sixteen patients (39%) had groin wound complications. Ten patients (24%) had evidence of contrast (endoleak) within the aneurysm sac on completion of the procedure. There were no obvious direct leaks from either the point of proximal or distal fixation. Seven of these endoleaks have resolved spontaneously. Two patients required additional procedures in the postoperative period to treat endoleak. The final patient has evidence of persistent endoleak on 3-month surveillance computed tomography scan. Major late problems occurred in 3 patients.

Conclusion: Patients with large abdominal aortic aneurysms and considerable cardiac comorbidity can safely undergo endovascular aneurysm repair. Femoral groin wound complications resulting in prolonged hospitalization remain the major cause of perioperative morbidity. In contradistinction to open aneurysm repair, long-term surveillance is essential to detect migration of the device and identify flow within the residual aneurysm sac—complications that could lead to aneurysm rupture following endovascular repair.

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The goal of abdominal aortic aneurysm repair is to prevent aneurysm rupture and prolong life. Traditional methods for repair of abdominal aortic aneurysm involve transperitoneal or retroperitoneal approaches. Recently, an alternative method for abdominal aortic aneurysm repair using endovascular techniques has received considerable attention in both the surgical literature and clinical practice. Few technologic advances have exhibited a comparable influence on the practice of vascular surgery as have the development of endovascular techniques presently used to exclude abdominal aortic aneurysms.

Since the initial report of successful endovascular exclusion of abdominal aortic aneurysms by Parodi et al in 1991, the philosophy regarding aneurysm repair has undergone considerable evolution in terms of delivery systems, types of stents, and graft fabric. Early experience suggests that at least in the short term, endovascular aneurysm exclusion is a feasible alternative to traditional open aneurysm repair. It is widely accepted, however, that the long-term durability of the procedure remains to be determined.

Considerable experience with various endoluminal devices has been documented in the surgical literature, yet until recently the actual practice of endovascular aneurysm repair has been limited mainly to academic centers.2-12 At the Medical College of Wisconsin in Milwaukee, we have developed an active practice for repair of abdominal aortic aneurysms using endovascular techniques. The present study represents our initial experience with endovascular aneurysm exclusion. The purpose of our review is to compare our experience with that described in the surgical literature. Additionally, we have analyzed our results to determine if any unique circumstances related to endovascular exclusion have arisen, which may influence our future ap-
PATIENTS AND METHODS

The present study includes all patients undergoing endovascular exclusion of abdominal aortic or common iliac aneurysms at the Medical College of Wisconsin (Froedert Memorial Lutheran Hospital or Clement J. Zablocki Veterans Affairs Medical Center). Two specific time periods are represented. The first extended from September 1997 to June 1998, during which the institution participated in the prospective comparison between open aneurysm repair and endovascular aneurysm exclusion using the previously available Vanguard system (Boston Scientific, Oakland, NJ) (n=11). The second time period extended from August 1999 to June 2000. This period represents our most recent experience with endovascular aortic aneurysm exclusion, and involves the use of 3 separate endovascular devices: (1) AneuRx (Medtronic, Sunnyvale, Calif) (n=17); (2) Ancure (Guidant, Menlo Park, Calif) (n=3); and (3) a custom-made device constructed with components manufactured by 2 companies (Cook Inc, Bloomington, Ind, and Sulzer Vascutech, Austin, Tex) (n=10). Both the AneuRx and Ancure devices were obtained commercially having recently been approved by the Food and Drug Administration (FDA) for clinical use. The custom-made device (Cook-AUI [aorto-unilateral iliac]) is an aorto-monoiiliac device developed by Krassi Ivancev, MD, of Malmo, Sweden.3 Permission for constructing and implanting the custom-made device was specifically granted as part of an Investigational Device Exemption from the FDA. A total of 41 patients are included in the present study.

The Medical College of Wisconsin serves as a tertiary referral center for southeastern Wisconsin. A considerable number of surgeons in the surrounding communities routinely perform open aneurysm repair. Most of the patients seen in the referral center had already been pre-screened for open aneurysm repair. At present with younger, good-risk patients, we recommend open operation, reserving the use of endovascular exclusion for patients with serious cardiopulmonary or additional comorbid disease. However, owing to the tremendous amount of information available to the general public, there are patients who demand the endovascular procedure if feasible.

RESULTS

Forty-one patients (35 men, 6 women) have undergone attempted endovascular exclusion of abdominal aneurysms. The number of patients treated by device are as follows: Vanguard, 11; AneuRx, 17; Ancure, 3; and Cook-AUI, 10. Mean patient age was 74 years (age range, 57-85 years). Clinical characteristics and comorbid disease are presented in Table 1.

Thirty-nine of the aneurysms treated involved the common iliac artery, with the remaining 2 involving the common iliac artery. Mean aortic aneurysm diameter was 6.13 cm (range, 4.9-11.9 cm), and iliac aneurysm diameter was 4.0 cm (range, 3.9-4.1 cm). The endoluminal device was successfully deployed in each of the 41 attempted procedures. There were no conversions to formal open aneurysm repair; however, one patient did require celiotomy to repair an iliac artery injury. This injury occurred early in our experience and was related to entrapment during aortotomy to repair an iliac artery injury. This injury occurred early in our experience and was related to entrapment of the delivery system within the iliac artery. Following arterial repair, the aneurysm was successfully excluded using endovascular techniques.

Duration of operation was calculated from time of initial incision to final wound closure. For the 41 procedures, the mean procedure duration was 171 minutes. Length of stay was calculated from date of operation to date of hospital discharge. Hospital stay ranged from 2 to 39 days, with a mean stay of 6.73 days. Average intensive care unit stay was 1.6 days (range, 1-4 days). Average procedure times and length of stay by device are further described in Table 2. Average blood loss was 484 mL (range, 200-2200 mL) (median, 500 mL). Thirteen (32%) of the 41 patients required red blood cell transfusion. Among these 13 patients, a total of 29 units of packed red blood cells were transfused (mean, 2.2 units; range, 2-6 units).

PREOPERATIVE EVALUATION

Each patient underwent routine preoperative cardiac evaluation consisting of either a Persantine thallium stress test or dobutamine stress echocardiography. Patients with functional test results consistent with inducible ischemia subsequently underwent coronary angiography as deemed necessary by a cardiologist.

Preoperative radiologic evaluation included computed axial tomography of the abdomen and pelvis using intervals no greater than 3 mm, with 3-dimensional reconstruction. Recently, computed tomography (CT) scans were obtained on a spiral CT scanner (General Electric LCA Scanner; General Electric Medical Systems, Waukesha, Wis) which provides 1.25-mm sections. Additionally, all but 1 patient underwent standard preoperative abdominal and pelvic arteriography. The CT scans and arteriograms were reviewed by both vascular surgical and interventional radiology staff to determine the suitability of aneurysm morphologic traits and geometry for endovascular repair. Once anatomic suitability was confirmed, a suitable device was chosen and operation undertaken.

Patients treated using the Vanguard system were deemed eligible for the procedure according to guidelines set forth by the investigators of the Vanguard clinical trial.3 More recently, we have considered all patients with asymptomatic abdominal aortic or common iliac aneurysms for endovascular repair. Patients receiving 1 of the remaining 3 devices were deemed eligible for the procedure if anatomic parameters were acceptable for the respective device. Aneurysm neck length of at least 15 mm was desirable for the AneuRx and Ancure devices. On occasion aneurysm necks less than 15 mm but greater than 10 mm in length were treated. Aneurysm necks as short as 7 mm were treated with the Cook device owing to its capability for transrenal fixation. The infrarenal segment had to have parallel walls and minimal angulation, especially in cases of short neck lengths. Aneurysm neck diameter sufficient to accommodate the respective devices and allow for appropriate oversizing of the graft was also necessary. Because of reliance on a friction fit for the AneuRx and Cook devices, grafts were purposely applied of the technique and subsequently the welfare of our patients.
Three patients have died since undergoing surgery. Two patients were treated during the Vanguard trial, 1 of whom died during the perioperative period. The perioperative death occurred suddenly at home, on the evening of hospital discharge. Preoperative cardiac catheterization demonstrated severe, untreatable coronary artery disease. Permission for autopsy was denied. One patient died in a nursing home 3 months following the operation, secondary to complications arising from pneumonia. The final death occurred 8 months after operation, secondary to complications arising from pneumonia. The final death occurred 8 months after operation, secondary to complications arising from pneumonia.

Complications have been categorized as systemic/remote or local/vascular as suggested by the committee on reporting standards. All patients experienced a total of 41 postoperative complications.

Six patients experienced systemic or remote complications. Three patients experienced cardiac-related complications, including one postoperative myocardial infarction. The other 2 patients developed postoperative atrial arrhythmias. One patient experienced perioperative pulmonary failure requiring intubation, and subsequently developed nosocomial pneumonia. There was 1 documented instance of atheroembolism, which resulted in elevated serum creatinine, which has since stabilized without the need for dialysis. The final systemic complication was prolonged ileus in a single patient, which resolved without intervention.

Local or vascular complications occurred in 24 patients. Sixteen patients developed groin wound complications consisting of dermal necrosis and/or superficial infection (12) and lymphatic leak (4). All wounds subsequently healed. A single patient experienced pseudoaneurysm formation, which was successfully treated with ultrasound-guided compression. This patient received the Vanguard device with the contralateral limb delivered via percutaneous arterial access. The remaining local complications consisted of scrotal hematoma (1), urinary in-
Continence (1), femoral nerve sensory neuropraxia (2), and abdominal wound infection in the patient who had celiotomy for repair of iliac artery injury.

In addition to the intraoperative perforation of an iliac artery, graft-related complications were identified in 3 other patients. Two implanted devices were found to have migrated on follow-up CT scans. Both migrations occurred in patients receiving the Vanguard device (Figure 3). Retrospectively reviewing both of these cases, the devices were undersized. One patient ultimately required explantation and underwent successful traditional open repair, while the second patient with migration underwent repair endoluminally by placement of a proximal extension cuff. The final patient experienced graft-limb thrombosis, which responded to thrombolytic therapy on 2 occasions but ultimately required a femoral-femoral bypass. The cause of the graft-limb occlusion was never detected. This was the only graft-limb occlusion in this series.

Ten patients left the operative suite with evidence of contrast (endoleak) within the aneurysm sac (Figure 4). No direct leaks (type I) from the proximal or distal fixation sites were identified. All leaks were indirect or transgraft leaks. Seven endoleaks have resolved spontaneously. Two patients underwent additional procedures to address residual endoleak evident on follow-up CT scan. These included embolization of lumbar artery and aneurysmal sac endoleaks. The final patient still had lumbar vessels visualized on 3-month postoperative CT scan. There was no contrast visualized within the aneurysm sac, and the maximum aneurysm diameter is unchanged. Our routine is to intervene and resolve all endoleaks that persist at 6 months from the operation.

### Table 1. Patient Clinical and Demographic Data*

<table>
<thead>
<tr>
<th>Patient Criteria</th>
<th>No. (%)</th>
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<tbody>
<tr>
<td>Male</td>
<td>35 (85.4)</td>
</tr>
<tr>
<td>Female</td>
<td>6 (14.6)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>31 (75.6)</td>
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<tr>
<td>Coronary artery disease</td>
<td>21 (51.2)</td>
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<tr>
<td>Previous myocardial infarction</td>
<td>12 (29.3)</td>
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<tr>
<td>Arrhythmia</td>
<td>10 (24.4)</td>
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<tr>
<td>Current or previous smoking</td>
<td>26 (63.4)</td>
</tr>
<tr>
<td>COPD</td>
<td>15 (36.6)</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>12 (29.3)</td>
</tr>
<tr>
<td>Cancer</td>
<td>12 (24.4)</td>
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</tbody>
</table>

*N = 41. COPD indicates chronic obstructive pulmonary disease.

### Table 2. Procedure Duration and Hospital Stay by Endovascular Device for 41 Patients

<table>
<thead>
<tr>
<th>Device</th>
<th>No.</th>
<th>Procedure Duration, min</th>
<th>Hospital Stay, d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vanguard (Boston Scientific, Oakland, NJ)</td>
<td>11</td>
<td>184, 180 (110-320)</td>
<td>6.1, 4 (2-23)</td>
</tr>
<tr>
<td>AneuRx (Medtronic, Sunnyvale, Calif)</td>
<td>17</td>
<td>224, 184 (120-415)</td>
<td>7.2, 5 (3-39)</td>
</tr>
<tr>
<td>Ancure (Guidant, Menlo Park, Calif)</td>
<td>3</td>
<td>190, 195 (120-255)</td>
<td>4.0, 4 (3-5)</td>
</tr>
<tr>
<td>Cook-AUI* (constructed with components from Cook Inc, Bloomington, Ind, and Sulzer Vascutech, Austin, Tex)</td>
<td>10</td>
<td>224, 220 (150-340)</td>
<td>7.2, 7 (4-9)</td>
</tr>
<tr>
<td>All devices</td>
<td>41</td>
<td>171, 195 (120-415)</td>
<td>6.7, 5 (2-39)</td>
</tr>
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*Aorto-unilateral iliac.

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Figure 1. Postoperative spiral computed tomographic scan with 3-dimensional reconstruction demonstrating placement of aorto-bi-iliac device.

Figure 2. Postoperative spiral computed tomographic scan with 3-dimensional reconstruction demonstrating placement of aorto-left iliac stent graft with femoral-femoral bypass. RT EIA indicates right external iliac artery; LRA, left renal artery.
The practice of endovascular aneurysm exclusion may ultimately represent one of the more important advances in vascular surgery. For this to be established, however, the technique must be carefully studied and validated by scientific and clinical investigation. Since its inception, the technique of endovascular aneurysm repair has undergone considerable change. As experience has accumulated, patients best suited to the procedure are more appropriately identified. At the same time, the technology responsible for continued improvement in device design has made the procedure available to a greater number of patients. At the Medical College of Wisconsin, the endovascular technique is being offered to any patient with suitable arterial geometry for endovascular repair. Like many other centers, our initial candidates for the procedure were patients who were likely unfit for traditional repair. As our experience has increased, we have become more comfortable with the technique and currently consider any patient with abdominal aortic or common iliac aneurysm a candidate for endovascular exclusion.

Although the current series is relatively small, our experience is unique in that we have accumulated experience with 4 different endovascular devices. This has allowed us to apply the advantage of a particular graft to a given clinical situation. For example, the AneuRx device has a smaller profile and requires a 22F catheter delivery system, which permits aortic access via smaller slightly tortuous arteries when compared with the other devices. Additionally, the availability of extension cuffs for use with the AneuRx system provides an element of flexibility in selecting iliac fixation sites. Larger iliac artery diameters may be accepted as distal landing zones owing to the ability to achieve an adequate seal by placement of extension cuffs.

The Ancure device, which has hooks at the proximal fixation site, is used in cases in which the aneurysm neck approaches 10 mm in length. It is our opinion that the hooks likely contribute to a more secure purchase of the aneurysm neck and may help to prevent future migration. The disadvantage of the Ancure device is that a 27F catheter delivery system is required for graft placement, making aortic access more difficult in patients with small-diameter iliac arteries. This is a particular problem in the presence of small iliac arteries, coupled with either tortuosity or notable calcification. The most obvious advantage of our custom-made device is that it provides an opportunity to treat patients whose proximal aneurysm neck diameter is greater than 26 mm. This has allowed us to increase the number of patients that may be treated by endovascular exclusion.

To date no difference has been identified in relation to endoleak or complication rates when comparing the respective devices. We believe that the frequency of complications is influenced more by the cumulative experience of the operative team rather than the individual device used.

For endovascular aneurysm repair to become the procedure of choice for the treatment of aneurysmal disease, the morbidity, mortality, and long-term success must be comparable to traditional aneurysm repair. The perioperative mortality in this series was 2.4%, which compares favorably with currently accepted mortality rates for open repair, which ranges from 3% to 5%.

Among our group of patients treated with endovascular aneurysm exclusion, we only experienced one perioperative death. This death was a sudden event, occurring in a patient enrolled in the Vanguard trial who died at home on the evening of hospital discharge. Unfortunately, the exact cause of death remains unknown, and permission for postmortem examination was denied. Our perioperative mortality for stent graft treatment of abdominal aor-
tic aneurysms compares favorably with series from centers of excellence reported in the literature, with reported mortality varying from 2% to 6%.7-12

In this study group there were no open complications and only 1 injury to an iliac artery that needed to be repaired with an open technique. This is at variance with the literature where conversion rates as high as 10% were published in earlier studies.4 This is a result of refinement of the delivery systems and the opportunity to benefit from work of early investigators. Our experience highlights the need to carefully select these patients, use high-quality imaging techniques for graft sizing, and combine excellent radiographic and surgical skills.

The single instance of iliac artery injury has led us to be particularly attentive to iliac artery anatomy. While iliac artery injury is not extremely common, it has been reported in the early experiences of other surgical groups.13 We have consistently chosen the side for delivery of the device preoperatively. Iliac artery tortuosity and calcification is noted preoperatively, and the potential need for predeployment maneuvers to enhance aortic access are discussed among the intended participants. This allows us to consistently have backup plans for attacking such difficult situations, which we believe has enhanced our success.

In addition to mortality, the morbidity of the procedure must also be examined. While our analysis does not include any direct comparison to patients receiving open repair, we have reached some interesting conclusions. Despite the minimally invasive nature of the endovascular procedure, the possibility for serious postoperative complications is not eliminated. We identified 6 patients who experienced systemic complications. Three patients had cardiac-related complications, including myocardial infarction and arrhythmias. One patient experienced pulmonary failure requiring mechanical ventilation. The remaining 2 patients experienced transient renal failure secondary to atheroembolism, and prolonged ileus.

We were surprised by the increased incidence of groin wound complications, which is greater than is reported in the literature.8,12 Having maintained an active lower extremity bypass practice, we are accustomed to the varied scope of postoperative problems related to groin incisions. Subsequently, it is our practice to place a great deal of attention to groin dissection and wound closure. We have consistently taken an aggressive approach to debridement and local wound care as necessary. It is possible that our increased incidence of groin-related complications is related to the number of obese patients treated at our institution. Another explanation may relate to the numerous catheter exchanges and extensive manipulations that take place within the groin incisions and are inherent to the procedure. As a result of our findings we have since adopted the use of transverse or oblique incisions placed just above the inguinal crease. We continue to open the femoral sheath using vertical dissection, once the subcutaneous tissue has been divided. Since adopting this technique, our overall incidence of groin wound–related complications has considerably decreased. Among the 21 additional cases performed since the completion of this analysis in which oblique incisions were used, we have only identified 1 groin-related complication. This was a lymphocele that resolved without surgical intervention.

One of the most widely quoted benefits of endovascular aneurysm exclusion is shorter hospital stay following the procedure.9,10 Among the initial 41 patients treated at our institution, the average length of stay was longer than 6 days. While our range for duration of hospitalization is quite broad (2-39 days), it has been our experience that most patients require at least 3 to 4 days to resume activity levels appropriate for hospital discharge. A closer examination of our length of stay data reveals that the average is slightly skewed by 2 patients whose hospital stays were 23 and 39 days. One patient developed a groin wound abscess, which required operative drainage and prolonged local wound care, while the second required prolonged mechanical ventilatory support in the immediate postoperative period. The same patient subsequently experienced bilateral groin wound dehiscence, with the remainder of his hospital stay dedicated to local wound care and rehabilitation. If median length of stay is observed, our data compare closely to initial experiences, which have been reported by other groups.10,14

We feel that the most appropriate explanation for our increased length of stay relates to the overall clinical profile of the patients treated. More than 50% of our patients were identified as having serious cardiac disease. Likewise, most were aged 70 years and older. It is apparent from our analysis and the degree of comorbid disease (Table 1) of most patients treated to date represent considerable overall operative risks. These patients may constitute a group in which aneurysmal disease would have previously gone untreated. It has been our routine to admit patients to the intensive care unit at least overnight. With increased experience we will in the future send some patients to the clinical floor following stent graft placement.

To definitively determine the future role of endovascular aneurysm repair in clinical practice, the long-term success of the technique must be verified. Perhaps one of the most prominent limitations regarding the technique relates to the need for perpetual, ongoing surveillance after the procedure is completed. As strategies regarding the appropriate management of postprocedure endoleak continue to evolve, a precise degree of attention must be provided to the postoperative care and radiographic surveillance of these patients. We have established a practice of obtaining postoperative CT scans at specifically defined intervals. Each patient receives an initial postoperative scan within the first month following the procedure. Subsequent scans are obtained at 3, 6, and 12 months from the operation. We have diligently examined postprocedure arteriograms to insure that no patient leaves the operative suite with an endoleak from either proximal or distal fixation sites. Likewise, follow-up CT scans are examined simultaneously by surgical and radiology staff to measure residual aneurysm diameter and identify the presence or absence of endoleak. From our initial series of patients, we have been fortunate that 7 of the 10 patients noted to have evidence of contrast within the aneurysm sac at the termi-
nation of the operation have spontaneously resolved their endoleak. Those patients, whose endoleaks do not spontaneously resolve, undergo intervention to eliminate the leak if it persists to the time of the 6-month postoperative CT scan, provided the maximum aneurysm diameter has not increased. Although we have not experienced a case of increased aneurysm diameter in relation to persistent endoleak, we would choose to intervene sooner if this were identified. Using this approach, despite the fact that our series to date is relatively small, we have not experienced delayed rupture in any patient treated with endovascular exclusion.

In conclusion, we feel that endovascular exclusion of abdominal aortic or common iliac aneurysms is a feasible alternative to traditional aneurysm repair, provided patient anatomy and aneurysm geometry is appropriate. While the potential for serious postoperative complications is not eliminated, patients with serious comorbid disease can be safely treated using endovascular techniques. It has been our experience that traditionally placed vertical groin incisions, particularly in obese patients, produce considerable risk for incision-related complications. Oblique groin incisions, placed just above the inguinal crease, reduce the incidence of groin wound-related problems. The learning curve associated with acquiring skills for intravascular placement of these devices is short provided the team possesses appropriate angiographic and surgical skills. The full commitment of all members of the vascular interventionalist team is essential to its success. The final analysis of this technique will depend on long-term studies. The effect of metal fatigue, increasing proximal aortic neck diameter with time, aneurysm remodeling, and the durability of the fabric remain to be determined. For the high-risk patient, this technique is a godsend. For the patient who will live 20 years, the jury is still out. The important aspect of this technique is that the patients need life-long surveillance to detect any potential problems that may occur.

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REFERENCES


DISCUSSION

Christopher K. Zarins, Stanford, Calif: I congratulate Dr Patterson on an excellent presentation and Dr Towne and the Medical College of Wisconsin team for embarking on a new program and teaching us some lessons on endovascular aneurysm repair. Endovascular repair has truly revolutionized our thinking in the way we approach and treat patients with aortic aneurysms. But, as with all new technologies and approaches, there is a learning curve. Dr Patterson has brought to light a number of the important lessons to be learned in adopting this new technology.

The first issue is the surgical approach to expose the femoral artery in order to introduce these endovascular devices. Dr Patterson reported an almost 40% incidence of groin necrosis and infection, a disturbingly high number. But he has also reported that we don’t have to make the standard vertical groin incision, and that a suprainguinal transverse oblique incision is actually a better approach. We agree and also prefer this approach because it provides access to the part of the femoral artery we really need to get to, that is, the proximal common femoral artery, which is soft and usually free of disease. It also allows more proximal extension if you need to deal with the external iliac artery or even extend up to the common iliac artery for access. We also use large introducer sheaths to allow removal of self-retaining retractors and avoid trauma to the groin area. We work exclusively through the large introducer sheaths and thereby reduce operative trauma.

Another possible factor in groin wound infection and necrosis may be the “cath lab” rather than the operating room environment. We have done some procedures in the cath lab although the vast majority of our procedures are done in the operating room. In the cath lab the operating table is wider, it’s not built for operations, in my experience the lighting is always somewhat suboptimal, and operating in that area is somewhat cumbersome. I also note that in the one case where an emergency conversion to celiotomy was required because of a ruptured iliac artery, that patient got a wound infection. So my first question is, is your high infection rate and groin complications problem related to the fact that you are doing these procedures in the cath lab rather than in the operating room, and will this possibly less-sterile environment potentially expose the patient to the risk of stent graft infection?

My second question relates to the endovascular devices themselves. The Wisconsin team has used 4 different devices. Each device has its own different learning curve and own specific and unique characteristics. How much of your learning
they understand what it is due to.

My third question relates to the overall patient management. Dr Patterson reports a hospital length of stay which was unusually long for endovascular procedures, almost 7 days. There was no difference in which of the 4 devices was used in this regard. This hospital length of stay is twice as long as that reported in the large FDA multicenter trials to approve the endovascular devices for commercial use. The elderly population with multiple comorbidities is the same in all of these trials. So what is the explanation for this prolonged hospital stay? I noted in the manuscript that you admitted patients the day before for IV hydration and mechanical bowel prep. Is this really necessary for endovascular aneurysm repair, and could this contribute to debilitating elderly patients, making them bedridden, and prolonging hospital stay? In our practice we admit patients on the day of surgery, feed them the evening of surgery, and ambulate them the next morning. Many are discharged on the first postoperative day, but the majority are actually discharged on the second or even third postoperative day. I am curious what your hospital length of stay for open surgery is in comparison to endovascular repair, because in most experiences, the hospital length of stay is one-third with endovascular repair compared to open surgical repair.

Finally, I would like to agree with Dr Patterson that the long-term outcomes clearly need to be better defined. There is no question that the patient morbidity is markedly reduced, patients recovered rapidly, earlier return to function, and endovascular approaches have been a great boon to patient care. I would like to thank Dr Patterson and the Wisconsin team for bringing this important information to our attention.

M. Ashraf Mansour, MD, Maywood, Ill: My question relates to your practice patterns. Do you screen all of your aneurysm patients to see if they are potentially candidates for endovascular repair? If you do so, what percentage of your aneurysm patients are eligible for endovascular repair?

Walter J. McCarthy, MD, Chicago, Ill: This is an interesting paper that will be helpful to centers getting started with one of these programs. You had a very successful rate of application of the devices, and iliac artery access is an issue for these patients. Can you detail your techniques for iliac access more completely for us? Secondly, please comment on patients who have a hypogastric orifice that comes off the edge of a common iliac aneurysm. Do you routinely embolize the hypogastric artery on one side, and do you routinely embolize the inferior mesenteric artery?

James R. DeBord, MD, Peoria, Ill: A number of these patients develop a postoperative fever of unknown cause. I am wondering if the Wisconsin group has experienced that and if they understand what it is due to.

Alexander D. Shepard, MD, Detroit, Mich: I wonder what your personal philosophy is when you are dealing with a relatively young, healthy patient who presents with an operable aneurysm. Are you advising these patients to undergo conventional, open repair to avoid the potential for problems 10 to 15 years down the road to also avoid the costs associated with long-term surveillance, or are you basically letting patients dictate the method of repair, afraid that they might end up going elsewhere where an endovascular repair might be available to them?

Dr Towne: Let me initially deal with Dr Zarin's comments. When we re-did our angio suite 4 years ago, we were successful in getting the hospital to literally bring up the angio suite to OR conditions, so in terms of air circulation and substerile rooms, it is not as easy to do an open operation on this angio table as in the OR, but it actually has worked out quite well. The problem we have with vertical groin incisions is that many of our patients are obese. When you consider these groin incisions can be open for 2, 3, and up to 6½ hours with multiple rotation exchanges, these wounds are vulnerable to wound-healing complications.

We have had experience with 4 devices and have been able to determine in what situation a device works better. With short aortic necks, we want internal fixation and will use the Ancure device. With an aortic diameter of 32 mm, where none of the FDA-approved devices fit, we use our homemade device. Also, with an angulated neck, I think the Ancure device is preferred because you are dealing with a proximal stent as the attachment site, and a nonsupported graft. The downside of this device is that is a 27F device vs the AneuRx, which is 21F. We have the test of all worlds, as we have a variety of devices that we can adapt to the individual patient.

The length of stay was due in part to the patient’s severe, co-existing diseases that were common in these patients. The initial patients were not candidates for open procedure.

Dr Mansour, I can’t tell you what percentage of patients had stented grafts. Many of these patients were selected by our referring physicians.

We will embolize the hypogastric artery at a separate sitting if we have to occlude it. We obviously don’t try to do it in both sides. In one case, both hypogastric arteries were occluded inadvertently during the procedure, fortunately without bowel ischemia. We never embolize the inferior mesenteric artery. I think in the future this may change as we look at the long-term course of endoleaks.

Dr Shepherd raises an important issue. With a young healthy patient, I recommend an open procedure. The leaders in this field have shown, in the short term, that endovascular grafts work. It is the long-term results that are not known. The incidence for additional procedures in the follow-up period indicates that caution should be used before these new techniques are used in all patients. We have been cautious, and we have followed these patients carefully. The final episode of this story is not in yet. The technology in this field is growing by leaps and bounds.