Impact of endovascular repair on open aortic aneurysm surgical training

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Purpose: The purpose of this study was to determine the impact of an endovascular stent-graft program on vascular training in open aortic aneurysm surgery.

Methods: The institutional and vascular surgery fellow experience in aortic aneurysm repair during a 6-year period was reviewed. The 3-year period before introduction of endovascular repair was compared with the 3-year period after introduction of endovascular repair. All patients undergoing abdominal aortic aneurysm (AAA) or thoracoabdominal aortic aneurysm repairs were entered prospectively into a vascular registry and retrospectively analyzed to evaluate the changing patterns in aortic aneurysm treatment and surgical training.

Results: Between July 1994 and June 2000, a total of 588 patients with AAA or thoracoabdominal aneurysms were treated at Stanford University Medical Center. There were 296 (50%) open infrarenal AAA repairs, 87 (15%) suprarenal AAA repairs, 47 (8%) thoracoabdominal aneurysm repairs, and 153 (26%) endovascular stent-grafts. The total number of aneurysms repaired per year by vascular fellows before the endovascular program was 71.3 ± 4.9 (range, 68-77) and increased to 124.7 ± 35.6 (range, 91-162) after introduction of endovascular repair (P < .05). This increase was primarily caused by the addition of endovascular stent-graft repairs by vascular fellows (51.0 ± 29.0/year [range, 23-81]). There was no change in the number of open infrarenal aortic aneurysm repairs per year, 53.0 ± 6.6 (range, 48-56) before endovascular repair versus 47.0 ± 1.7 (range, 46-49) after (P = not significant). There was a significant increase in the number of suprarenal AAA repairs per year by vascular fellows, 10.0 ± 1.0 (range, 9-11) before endovascular repair compared with 19.0 ± 6.5 (range, 13-26) after (P < .05). There was no change in the number of thoracoabdominal aneurysm repairs per year between the two groups, 8.0 ± 3.0 (range, 4-11) before endovascular repair compared with 7.6 ± 2.3 (range, 5-9) after.

Conclusions: Introduction of an endovascular aneurysm stent-graft program significantly increased the total number of aneurysms treated. Although the number of open aneurysm repairs has remained the same, the complexity of the open aneurysm experience has increased significantly for vascular fellows in training. (J Vasc Surg 2001;34:885-91.)

Modern treatment of abdominal aortic aneurysms (AAAs) finds its origin in the procedure reported by Dubost in 1951—resection of the aneurysm and direct graft replacement. During the past 50 years, surgeons throughout the world have adopted, modified, and perfected Dubost’s strategy of direct aneurysm repair and established aortic reconstruction as the treatment of choice for most AAAs. The development of improved prosthetic grafts, vascular sutures, and clamps, refinements in operative technique, and improvements in perioperative care have improved safety and effectiveness and established direct graft replacement of aneurysms as the standard of care. It is these techniques that have been taught to both general surgery residents and vascular surgery fellows during training. With the introduction of less invasive endovascular aneurysm repair using stent grafts by Parodi in 1991,2 the possibility of replacement of open repair by endovascular repair has been raised. Some have reported that as many as 20% to 80% of patients will be treated with endovascular repair.3-6 This raises the possibility that the number of open repairs by vascular trainees will dramatically decrease and not meet the specified number required by the residency review committee.

The purpose of this study was to review our aneurysm experience during the last 6 years, following the development of an endovascular stent-graft program, to evaluate the institutional pattern of AAA repair and the effects on open aneurysm repair for vascular fellowship training. We examined the number and type of open abdominal aneurysm repairs before and after the initiation of this program.

METHODS

From July 1994 through June 2000, 588 patients underwent elective surgical or endovascular reconstruction of AAAs or thoracoabdominal aortic aneurysms. This period was comprised of 3 years before and 3 years after the implementation of an endovascular stent-graft program. Aneurysm repairs before the addition of endovascular repair occurred between July 1994 and June 1997, and...
repairs after the addition of endovascular repair occurred between July 1997 and June 2000, after the initiation of a stent-graft program. An endovascular stent-graft program for repair of AAAs with the bifurcated AneuRx stent graft (Medtronic AVE, Santa Rosa, Calif) began in 1997. This began with a pilot program involving the Phase I AneuRx clinical trial in October 1996. The endovascular program involving fellows began in July 1997.

The AneuRx stent graft is a modular graft made of woven polyester fabric with an outer self-expanding nitinol skeleton. Patients who were considered for endovascular repair were presented to a panel of vascular surgeons and radiologists who reviewed the aneurysm morphology and decided on the appropriateness of endovascular repair. These patients’ computed tomographic scans were often referred in consultation without being evaluated in the clinic. Patients who were not suitable candidates for endovascular repair were referred for open repair.

All patients were entered prospectively in a vascular registry and retrospectively analyzed to evaluate the changing patterns in open aortic aneurysm training in a vascular surgery fellowship. There was one clinical vascular fellow per year performing all major vascular reconstructions with an attending vascular surgeon present. Aneurysm repairs were classified into four groups—open infrarenal, open suprarenal, thoracoabdominal, and endovascular stents. Ruptured aneurysms (n = 59) were not included in this analysis.

We reviewed the number and complexity of repairs before and after initiation of the stent-graft program. Complexity was defined as suprarenal repair and/or the number of branch vessel reconstructions performed.

Data were analyzed with the Student t test and χ² test as appropriate. A P value of less than .05 was considered significant. All values are expressed as mean ± standard deviation.

RESULTS

Between July 1994 and June 2000, 588 aneurysms were repaired. The combined 30-day operative mortality for all patients was 4% (24/588). There were 296 (50%) open infrarenal AAA repairs, 87 (15%) suprarenal AAA repairs, 47 (8%) thoracoabdominal aneurysm repairs, and 153 (26%) endovascular stent grafts during the period of the study. There was one intraoperative conversion of an endovascular repair to open surgery because of inability to obtain satisfactory proximal fixation in a markedly tortuous infrarenal neck. This patient had an uneventful postoperative recovery and was included in the total number of open infrarenal repairs. There were a total of six clinical vascular fellows during the study period (1 fellow/year).

The mean number of aneurysms repaired by trainees per year before the initiation of a stent-graft program was 71.3 ± 4.9 (range, 68-77). This number remained constant during these 3 years (Fig 1). However, after a stent-graft program was begun, the mean number of aneurysm repairs significantly increased to 124.7 ± 35.6 (range, 91-162) (P < .05). This number also significantly increased each year during the second 3-year period (Fig 1).

The overall distribution of aneurysms repaired by fellows with appropriate supervision is shown in the Table. The relative number of open infrarenal AAAs repaired is constant (Fig 2). There was no change in the number of open infrarenal AAA repairs per year, before (53.0 ± 6.6 [range, 48-56]) versus after (47.0 ± 1.7 [range, 46-49]) (P = not significant [NS]) the endovascular stent-graft program. The number of thoracoabdominal aneurysm repairs also remained constant each year (Fig 2). There was no difference in the number of thoracoabdominal aneurysm repairs per year between the two groups—before endovascular repair, 8.0 ± 3.0 (range, 4-11) compared with after endovascular repair, 7.6 ± 2.3 (range, 5-9) (P = NS).

There was an annual increase in the total number of aneurysms repaired (open and endovascular). The number of open repairs increased by a maximum of 13 aneurysms per year. This increase was caused by the number of suprarenal aneurysms repaired beginning in 1997 after the initiation of the stent-graft program (Fig 2). The major
The introduction of endovascular aneurysm repair has increased the number of patients with AAAs who are candidates for aneurysm repair because patients with severe comorbidities can be treated. Although some authors have performed aortic aneurysm repair in high-risk patients with acceptable morbidity and mortality, these patients are often excluded from open repair because of prohibitive comorbidities. Estimates regarding the eligibility rates of patients with infrarenal AAAs for endovascular repair range from 20% to 80%. This has raised the possibility that there will be a reduction in the number of open aortic aneurysm repairs and that this will have an adverse impact on the train-
ing of future vascular surgeons in open aneurysm repair. The purpose of this study was to define whether an endovascular stent-graft program has an initial positive or deleterious effect in the training of vascular surgeons.

In October 1996, an endovascular aneurysm treatment program was instituted at Stanford University. This began as part of a multicenter clinical investigation of a new endovascular device (AneuRx stent graft) and continued after Food and Drug Administration approval of the AneuRx stent graft in September 1999. Vascular surgery fellows are trained in open aneurysm repair during the first year and in endovascular repair during the second year of a 2-year fellowship program. The focus of this investigation was the open AAA surgery experience of six fellows. Three of the fellows trained before initiation of the endovascular treatment program and were actively involved with the clinical care of aneurysm patients only during the first year of the 2-year fellowship. The other three trained after the institution of the endovascular program and were involved with aneurysm treatment in both years of the 2-year vascular fellowship.

The overall number of patients with AAAs treated at Stanford University Hospital increased during the 6 years of the study. This appeared to be caused primarily by the introduction of the endovascular treatment program as a result of increasing referral of patients with AAAs and treatment of a number of patients with severe comorbidities who would have been previously excluded from open repair because of excessive surgical risk. We have previously shown that the number and type of open aneurysm repairs did not change significantly.10 However, in that study, the aneurysms were classified only as simple or complex aneurysms. Simple aneurysms were defined as infrarenal, and complex included suprarenal and thoracoabdominal aneurysms and infected grafts. In this study, we looked in greater detail at the complexity of aneurysm repair and at the type and number of branch vessel reconstructions and the role performed by vascular trainees.

The overall number of total (open and endovascular) aneurysm repairs performed by vascular fellows during their 2-year training experience increased two-fold. This increase is primarily a result of the addition of endovascular repairs during the second year of training. The number of open infrarenal and thoracoabdominal aneurysms remained constant during the study period. However, there was a significant increase in the number of suprarenal aneurysm repairs performed during the first year of training, but not to the same extent as the number of endovascular repairs. This increase likely reflects the increase in patients referred for consideration of endovascular repair who were not suitable candidates. The majority of these patients (51/138) were not candidates because of absence of a suitable infrarenal neck, thus requiring suprarenal repair. Each year, as the number of endovascular repairs increased, the number of suprarenal repairs increased accordingly. The greatest part of the endovascular experience occurred within the framework of the multicenter AneuRx clinical trial. After the Food and Drug Administration approved the AneuRx stent graft on September 28, 1999, the device became widely available. However, no change in referral patterns has yet been observed. As more physicians become trained in endovascular repair of AAAs, it is possible that the total number of aneurysms repaired at our institution may decrease as the number of endovascular referrals decrease. However, with the availability of a less invasive technique to repair aneurysms, which is applicable to high-risk patients with multiple comorbidities, it is possible that the total number of aneurysms diagnosed and referred for treatment from primary care specialties will increase.
The number of branch vessel reconstructions has also increased significantly as a result of the rising number of suprarenal AAAs in open surgery. The number of mesenteric, inferior mesenteric, and hypogastric artery reconstructions has remained relatively constant during this period. However, as the number of suprarenal aneurysms increased, there was also a significant increase in the number of renal artery reconstructions performed concomitantly with aneurysm repairs. The numbers in this report reflect the number of aneurysm repairs performed by vascular fellows during their clinical training at Stanford University Hospital. Chief residents in the Stanford General Surgery Training Program perform the majority of their vascular reconstructions at three affiliated hospitals that are just beginning to perform endovascular aneurysm repairs. There has been no change in the experience of the general residents in the treatment of aortic aneurysm and no impact of the endovascular program on general surgery resident case numbers.

In an attempt to increase eligibility for patients with short and wide necks, stent grafts that anchor above the renal arteries with an uncovered stent portion have been designed. Whether this type of fixation will increase the eligibility rate of endovascular repair and prove to be safe and durable remains to be seen. If these types of grafts prove to be effective in the future, then the overall number of open aneurysms may decrease.

Endovascular aneurysm repair is a safe and effective treatment of AAA. The addition of an endovascular program to a vascular fellowship is beneficial because it has increased the fellows’ experience with both open and endovascular repair. The total number of aneurysms repaired per year increased, whereas the total number of open infrarenal and thoracoabdominal aneurysm repairs remained constant. The most difficult and challenging aortic reconstructions, suprarenal aortic aneurysm repair with branch vessel reconstruction, increased significantly for the vascular fellow in training. Thus, there is a beneficial effect on training as the level of complexity rises.

REFERENCES
DISCUSSION

Dr Luis Sanchez (St Louis, Mo). Good morning. It is really a pleasure to have the opportunity to discuss this paper and to review the manuscript that you sent to me well in advance. This presentation addresses a very important issue of training vascular surgeons in the era of endovascular repair of abdominal aortic aneurysms which is continuing to increase. Some authors over the last few years have suggested that up to 80% of the open surgical procedures we perform will be replaced with new vascular techniques, mainly endovascular techniques. This is already occurring with the common use of endovascular techniques in a variety of problems and the treatment of aortoiliac aneurysms is no exception to this situation.

While some high-volume fellowships like yours and the ones that I participate in at Washington University in St Louis will be able to maintain an acceptable level of experience for the vascular trainees, and as you have shown may even increase it, for endovascular and open surgical techniques, many other institutions may not be able to, and that is still a real concern with the training of our vascular fellows and residents in general. Other institutions may have significant difficulties in maintaining acceptable levels of open endovascular cases in their general surgery and vascular fellowships to really obtain enough technical expertise to be able to perform all these procedures appropriately and safely. I think it is going to be necessary to make significant changes in the training of vascular surgeons to assure their competence in endovascular as well as open surgical techniques. I have a few questions and comments on your paper which was extremely well written and had a lot of great information.

Do your fellows really spend 2 separate years in clinical training, one concentrating on open surgical techniques and another one on endovascular techniques? If that is the case, do you think that most vascular fellowships should move to 2 years of full clinical training in addition to research training that many fellowships do include as their second year?

In your experience, approximately 64% of your patients with infrarenal aneurysms underwent endovascular repair, which is a reasonable number. Do you think that the percentage of these patients will continue to increase as new transrenal devices and larger devices become available, thus further limiting the number of open procedures that may be available for the trainees?

Most fellowships also exist in a close relationship with general surgery training residencies, and in your program there is a specific and unique relationship of the two that may not affect the training of the general surgery residents, but obviously in many centers the number of cases are divided between the vascular fellows and the general surgery residents. How do you see this affecting the training in the future at many centers?

Clearly, many tertiary care centers have had a significant increase in the number of patients with AAAs that are seen just like yours, at least in the initial experience of using endovascular devices. Do you think that this is going to be a long-term effect for many of these sites, or as other centers and other specialists start doing endovascular procedures would those numbers change and decrease the available experience for our fellows?

Thank you very much for the opportunity to discuss this paper.

Dr Frank R. Arko. Thank you, Dr Sanchez, for those insightful and thoughtful questions. With regards to the training at Stanford University, it is split into basically a 2-year fellowship. The first year is a clinical fellowship, and we perform all the open cases during that year. We have a large number of faculty, and every day we spend our operative day with a different faculty. The second year is split between doing endovascular and research. The individual fellow can design it however he really wants to with regards to his research interest, but all the endovascular cases are performed during the second year. All the cases are routinely sized and measured by the second-year fellow, and we get a lot of other training in endovascular techniques by going to two other surrounding hospitals where we perform other peripheral cases.

The next question was that the current number of endovascular cases we perform is around 64%. The majority of these cases were done during a phase I, II, and III clinical trial of the AneuRx stent graft. The number of endovascular cases has certainly increased, and we have not looked at it recently, but I believe it is greater than 64%. As the number of suprarenal fixation comes into play, the overall number of open infrarenal repairs may gradually decrease.

The next question was with regard to general surgery training, and I did mention this in the manuscript but I did not mention it in the talk. At Stanford University, there are four hospitals. There is the VA, a county hospital, Kaiser-Permante, and Stanford University Hospital. As a fellow, the only hospital that you operate at is Stanford University, and the vascular team consists of the fellow, a third-year resident, a second-year resident, and a first-year resident. The general surgery residents do not participate as the primary operator in any of the open infrarenal repairs as third-year residents and they get all their training in open infrarenal repairs at the VA, the county hospital, and Kaiser-Permante. None of these institutions are currently placing endografts. The VA does put in a few but not that many.

The last question was, as we train the people in the surrounding community do I think the numbers will decrease. Currently, as you know, after the AneuRx was FDA approved there were several trainings for outside physicians to be done, but that gradually decreased as there was a problem getting the graft, and so there have not been that many training courses performed. I do know that in the surrounding community, we train most of the vascular surgeons to put in stent grafts and the total number of stent grafts placed in Northern California, which is the area that Stanford encompasses, has been around 294, the majority of those performed by vascular surgeons. Six percent of those were per-
formed by cardiologists and a very, very low number performed by general surgeons. As of yet, it has not affected the number of repairs that we have done; however, the referral patterns may decrease and we may see a change in the future.

Dr Keith Calligaro (Philadelphia, Pa). I would like to ask you a follow-up question to something Dr Sanchez posed to you. I ask you to divorce yourself from your feelings for Stanford and think of the more common situation facing other hospitals. It makes sense that hospitals that do aortic stent grafts increase the volume of aneurysms that will be referred. That has certainly happened at our institution. The point is, if you get an increased number of infrarenal aneurysms that are straightforward, they will be treated by stent grafts; your fellows will do those and their numbers will increase. You will get referred more complicated aneurysms simply that cannot be treated that way, so your fellows’ experience will again increase. I still have trouble understanding how the general surgery residents’ experience cannot suffer from the explosion of endovascular techniques. The question I have for you is, how do you see the training for general surgery residents possibly changing in the future and vascular surgery fellows’ training changing? The program directors of vascular surgery are facing a very critical issue as to should there be a 3-year general surgery training and a 3-year vascular, or should general surgery residents maybe even get less exposure to aneurysms simply because they are not going to be as many of them for them to do?

Dr Arko. Those are all very reasonable questions. I believe that as endovascular repairs increase, the general surgery experience with open aneurysm repairs will decrease. On the west coast, most general surgery residents who go out and practice are currently not doing very much vascular surgery in the communities of Northern California. There are very few general surgeons performing vascular surgery. However, in the Midwest, there is not a high concentration of vascular surgeons, and a lot of the vascular surgery is being performed by general surgeons. There have been some general surgeons who have gone through some of these training courses and learned how to do endovascular repairs of aneurysms. I personally am not sure that is a good solution to the problem. Often a 2-day training course followed by proctoring is used to teach these techniques which can be fairly complex. It may be that in the future there is less vascular surgery performed by general surgeons.

Dr Peter Lawrence (Irvine, Calif). I think you did a great job of telling us what happened at your institution. I think what many of the questions are dealing with trying to tease out where these patients came from. My question has a little bit to do with the concerns that many community physicians have about issues related to bait and switch. In other words, having a program where patients come for what seems to be a need for an endovascular repair that end up with a routine elective surgical procedure. Do you have any information on how many of your infrarenal aneurysm repairs initially were referred for endografts and then end up undergoing surgical procedures? In other words, what was the sorting out is of where those patients came from and what the initial indication was for the referral to Stanford as opposed to staying in a community setting?

Dr Arko. Again, a very good question. I do not have the exact numbers for you, but a lot of the patients who were referred for endovascular repair, especially during the phase I, II, and III clinical trials, when they were seen and not found to be an endovascular candidate, the patient was certainly given the opportunity to go back to their community hospital. Now, most of the patients who were referred to Stanford were referred for severe comorbid conditions. The patients were sent there because they did not think that they could undergo an open operation and sent there for possible stent graft. Those patients who were not stent-graft candidates tended to stay at Stanford to have their open repair performed. I think that is mainly the rise that you see in the number of suprarenal repairs that we perform, but I do not have the exact numbers for you.

Dr Enrico Ascher (Brooklyn, NY). So, you think that in 5 years you will be presenting similar data, or do you think that in 5 years, as the community hospitals get to do more of these and get more facile with the procedure, because remember the overall number of aneurysm repairs has not really increased, so obviously there is just a migration of patients from one area to the other because of these new devices and new operations, but do you think that in 5 years you are going to be as optimistic as you are now?

Dr Arko. That will be hard to predict. Certainly at Stanford University Hospital you may be doing more open complex operations, as the number of straight-forward infrarenal AAA repairs are performed in the community with endovascular techniques. Certainly, referral patterns are changing continuously. Furthermore, long-term results of endografts are still unknown, and I am not sure that community physicians will want to be dealing with the secondary procedures often required for aortic stent grafts. This includes dealing with more complex endovascular repairs, endoleaks, and migration. Again, I do not think the overall experience will change, but I think the complexity of the repairs will increase. Thank you.