# Adding an endovascular aortic surgery program to a rural regional medical centre

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**Background:** Abdominal aortic aneurysms requiring surgical intervention are generally treated by endovascular means. Such procedures are not always offered in rural hospitals, possibly leaving patients underserved. We reviewed our experience initiating an endoaortic surgery program.

**Methods:** A surgeon in a rural centre was credentialed to perform endovascular aortic aneurysm repair through collaboration with a university centre and was proctored locally for the first 5 abdominal aneurysm repairs. Web-based image storage was used to review complex cases as part of an ongoing partnership. Referred patients were screened for multiple aneurysms and underwent long-term monitoring.

**Results:** In all, 160 patients were evaluated for 176 aortic pathologies. Twenty-five patients (17 men) aged 55–89 years underwent 26 endovascular abdominal ($n$ = 23) or thoracic ($n$ = 3) aortic procedures. Emergent endovascular procedures were not performed. There were no operative deaths, requirements for dialysis or conversions to open repair. Two endoleaks required early reintervention. The median length of stay in hospital for endovascular procedures was 2.5 days. Chronic endoleaks were observed in 7 patients. An additional 8 patients underwent open abdominal aneurysm repair locally and 15 patients were referred to the university program.

**Conclusion:** Creation of an endovascular aortic surgery program in a rural hospital is feasible through collaboration with a high-volume centre. Patient safety is enhanced by obtaining second opinions using web-based image review. Most interventions are for abdominal aortic aneurysms, but planning for a comprehensive aortic clinic is preferable.

**Contexte :** Les anévrismes de l'aorte abdominale justiciables d'une intervention chirurgicale sont généralement traités par voie endovasculaire. Ce type d'intervention n'est toutefois pas toujours pratiqué dans les hôpitaux ruraux. Les patients peuvent donc s'en trouver moins bien desservis. Nous avons passé en revu notre expérience après la mise sur pied d'un programme de chirurgie endoaortique.

**Méthodes :** Grâce à une collaboration avec un centre universitaire, un chirurgien d'un centre rural a reçu l'agrément nécessaire pour effectuer la réparation endovasculaire des anévrismes de l'aorte et il a été supervisé localement pour les 5 premières réparations d'anévrisme de l'aorte abdominale. Une banque d'images sur le Web a permis de passer en revue des cas complexes dans le cadre d'un partenariat continu. On a fait subir aux patients adressés en consultation un dépistage d'anévrismes multiples et ils ont fait l'objet d'un suivi à long terme.

**Résultats :** En tout, 160 patients ont été examinés pour 176 anomalies aortiques. Vingt-cinq patients (17 hommes) âgés de 55 à 89 ans ont subi 26 interventions endovasculaires de l'aorte abdominale ($n$ = 23) ou thoracique ($n$ = 3). Aucune autre intervention endovasculaire n'a été effectuée. On n'a eu à déplorer aucun décès en lien avec les interventions, aucun recours à la dialyse ni conversion vers une chirurgie ouverte. Deux endofuites ont nécessité une réintervention précoce. La durée médiane du séjour hospitalier dans les cas d'intervention endovasculaire a été de 2,5 jours. Des endofuites chroniques ont été observées chez 7 patients. Huit autres patients ont subi une réparation ouverte d'anévrisme abdominal localement et 15 patients ont été référés au programme universitaire.

**Conclusion :** La création d'un programme de chirurgie de l'aorte endovasculaire dans un hôpital rural est réalisable grâce à une collaboration avec un centre dont le volume d'interventions est élevé. La sécurité des patients est renforcée par l'obtention de secondes opinions facilitées par une banque d'images sur le Web. La plupart des interventions concernent des anévrismes de l'aorte abdominale, mais il est préférable de planifier la mise en place d'une clinique où on pourrait intervenir sur toutes les portions de l'aorte.

Open aortic aneurysm repairs can have high complication rates because many patients undergoing this type of surgery have comorbidities, mostly related to advanced age.[1,2] Since Parodi and colleagues[3] reported their experience using intraluminal graft implants to treat aortic aneurysms, less invasive endovascular aortic aneurysm repair (EVAR) of abdominal aortic aneurysms (AAA) has become applicable in up to 75% of cases requiring intervention.[4–6] Such technology is also applicable, albeit to a lesser extent, for thoracic endovascular aortic aneurysm repair (TEVAR). Despite questions about long-term benefit and potentially higher up-front costs, these procedures are more appealing because they have significantly lower 30-day morbidity and mortality.[7–11]

Adding an endovascular aortic repair program to an existing surgical product line may not be possible because there could be too few vascular cases to attract a vascular surgeon.[12,13] In such instances, local general surgeons often have provided open vascular surgery services, including abdominal aortic aneurysm repair. These vascular services may be complemented by interventional radiology and cardiology for catheter-based treatment of iliac and lower extremity arterial disease. Alternatively, a rural hospital may try to attract a dually specialized surgeon who has qualified in both general and vascular surgery. Such surgeons, however, frequently wish to limit their practices to vascular surgery. The majority of general surgeons do not receive sufficient vascular training to provide endovascular aortic aneurysm repairs.

Under these circumstances, rural physicians must refer patients requiring treatment for aortic aneurysm disease to distant hospitals.[13–15] Unless a local physician or surgeon is motivated to regularly follow such patients before and after intervention, there is a risk of creating an underserved population. An appropriately qualified surgeon at a rural medical centre would allow the hospital to manage these patients comprehensively. In this paper we describe how a regional hospital serving a population of 250 000–500 000, Bayhealth Medical Center (BMC), implemented such an aortic clinic and stent graft surgery program. A partnership with a distant university medical centre, the Hospital of the University of Pennsylvania (HUP), was initiated to facilitate the introduction of endovascular aortic procedures.

## Methods

An accredited institutional review board approved this retrospective study and waived the requirement for patient consent.

### *Endovascular working group and timeline*

Before creation of the endovascular surgery program, it was necessary to establish a hospital working group. An administrator oversaw representatives from surgery, anesthesia, clinical engineering, the cardiovascular operating room and diagnostic imaging. The group was tasked with the generation of a timeline, credentialing guidelines and contracting with a high-volume vascular surgery program. Credentialing guidelines were developed with the guidance of the director of the local cardiac catheterization laboratory. An 8-month timeline laid out monthly goals for the endovascular working group. It included the credentialing process, the purchase of a new C-arm fluoroscopy machine, training the operating room (OR) nursing staff and ordering necessary endovascular inventory items. The inventory list was compiled by the surgeon being credentialed (D.M.). Our timeline is presented in the Appendix (available at cms.ca/cjs). The working group met every 2 weeks and reported its progress toward starting the endovascular service.

### *Joint venture with high-volume vascular surgery service*

The BMC is in a county that is code 3 on the U.S. Department of Agriculture's census-based Rural–Urban Continuum Codes (RUCC) and serves a small metro area with a population of about 250 000; BMC also partially serves an adjacent county that is code 4. The HUP is in a county that is code 1 on the RUCC system. It is in a large, metro area with a population of about 6 million and

**Table 1. Procedures completed by D.M. during training with HUP surgeons**

| Procedure | Assist at HUP | Operator at HUP | Operator at BMC | Total procedures | Required total |
|---|---|---|---|---|---|
| EVAR procedures | 9 | 2 | 5* | 9 assist<br>7 operator | 5 assist<br>5 operator |
| Open AAA | 4 | | | 4 | 2 suggested |
| Diagnosic aortoiliac procedures | 41 | 20 | 10* | 41 assist<br>30 operator | 15 assist<br>15 operator |
| Interventional aortoiliac procedures | 20 | 9 | 10* | 20 assist<br>19 operator | 15 assist<br>15 operator |
| TEVAR procedures | 6 | | | 6 | 10 |

AAA = abdominal aortic aneurysm; BMC = Bayhealth Medical Center; EVAR = endovascular aortic aneurysm repair; HUP = Hospital of the University of Pennsylvania; TEVAR = thoracic endovascular aortic aneurysm repair.
*Cases completed during the first 5 proctored cases at BMC.

is located about 80 miles from BMC.[16] The HUP has made a major commitment to heart and vascular care. The partnership between BMC and HUP increases their outreach and facilitates the referral of BMC patients with complex aortic pathology to be treated at HUP. These patients can then be treated by specialized surgeons with state-of-the-art equipment that is not available at BMC. An example of this would be a hybrid operating room suite. Such a suite can have better imaging equipment and usually has a larger inventory of specialized catheters needed for unusual and complex cases. In return for financial compensation, BMC may use HUP's brand identity in advertisements and community outreach. The HUP surgeons obtained credentials that allow them to assist or proctor up to 6 cases per year at BMC. The BMC surgeons may also work in partnership with HUP surgeons on complex cases by having privileges at both hospitals. The BMC surgeons can consult rapidly with HUP surgeons on complex cases using web-based imaging services, deciding whether to treat patients locally or refer them.

### *Credentialing guidelines and process*

Patient evaluation and selection started 6 months before the first expected EVAR procedure during the credentialing period. During this time, urgent, emergent and more complex cases were referred to the university centre for earlier treatment or enrolment into newer graft trials. A BMC cardiac surgeon (D.M.) spent 3 days per week at HUP assisting in or performing endovascular procedures. During the 6-month training period, a list of usual wire and catheters needed for EVAR and TEVAR procedures was developed so that the working group could make contact with vendors.

Because endovascular aortic surgery was a new procedure for our hospital, there was no established credentialing policy. We therefore developed a credentialing policy for EVAR and TEVAR. The policy included both a didactic and procedural portion. The didactic portion included reading a relevant textbook and taking an accredited or approved education program on EVAR procedures. For the procedural portion, the surgeon was required to participate in a specified number of endovascular procedures. The number and type of required procedures for each module are listed in Table 1. These were based on Society of Vascular Surgeons and American College of Cardiology guidelines.

The surgeon must act as operator (while proctored by a qualified surgeon) in at least half of the required procedures (excluding TEVAR procedures). Each endovascular abdominal aneurysm repair case was counted as 1 EVAR procedure, 2 aortoiliac intervention procedures and 2 aortoiliac diagnostic procedures. The TEVAR cases counted similarly, but without aortoiliac intervention. The surgeon (D.M.) satisfied most of the procedural credentialing requirements on cases at HUP then completed these requirements in the first 5 cases at BMC. These were preplanned with an HUP surgeon (E.W.) acting as a proctor. This satisfied the standard focused professional practice evaluation (FPPE) required by the BMC medical staff office. A detailed count of completed cases is presented in Table 1. Collaboration with HUP surgeons allowed the surgeon to complete his training and fulfill his procedural credentialing requirements. The TEVAR credentials were not rigorously met, but the hospital credentialing committee felt the overall experience was sufficient to sign off.

### *Imaging*

Because of the intensive planning required before an endovascular procedure, high-quality computed tomography (CT) imaging studies are essential to the surgeon. The collaborative nature of the BMC endovascular service line necessitated rapid sharing of imaging studies with HUP surgeons. When starting our endovascular service line, we considered several imaging programs. One of the most important criteria for our imaging system was that it must allow for easy and seamless remote image sharing. We chose the PEMS software package (M2S). With this software, BMC computed tomography angiography (CTA) films can be uploaded and processed into 3-dimensional (3D) images upon email request. Viewing software can be downloaded on any computer, and M2S-generated 3D images can be easily downloaded and stored locally for physician evaluation. M2S acts as an intermediary between

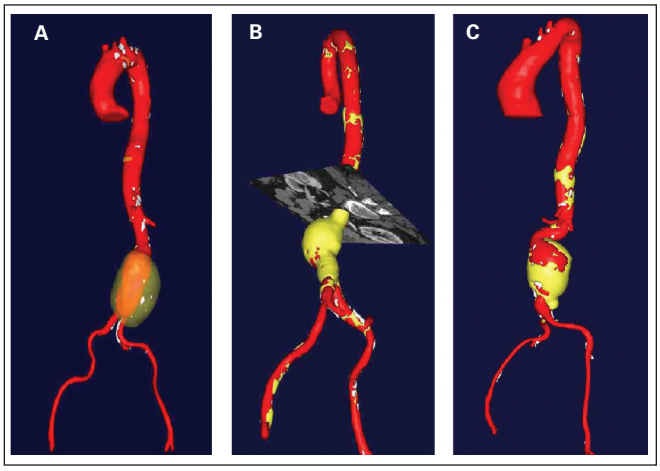


**Fig. 1.** Example images from the M2S software package. (**A**) A patient who will undergo endovascular aortic aneurysm repair (EVAR) at Bayhealth Medical Center. (**B**) A high-risk EVAR due to thrombus in the proximal neck. This patient would be referred to the Hospital of the University of Pennsylvania. Note how a tomographic slice can be placed onto the aortic contour, orthogonal to the bloodpath. (**C**) Anatomy requiring open repair or a new generation graft adapted to severe neck angulation. All patients were screened for multiple aneurysms with chest, abdomen and pelvis imaging.

BMC and HUP surgeons, as BMC films can be dropped directly into a HUP surgeon's (E.W.) folder, upon request. Isolated surgeons can then view the same film from their respective login points. This avoids having to physically send and receive films, which can be costly and time-consuming. Another important criterion for the imaging program is high-quality image reformatting. The program we chose has the ability to map thrombus and calcium along blood-paths. This feature facilitates endovascular graft planning, as seen in Figure 1.

### *Local surgeon partnership*

Before starting this program, patients with AAA were referred by primary care physicians to the local private general surgery groups for open repair or were referred to various city hospitals. After instituting this program, many patients underwent endovascular repair by the BMC (D.M.) or HUP surgeons. The ability of the endovascular program to treat simple cases has left the more complex cases for open repair. Partnering with a local general surgeon became important to treat complicated cases requiring open repair. This has helped refine surgical techniques for open AAA repair.

### *Clinical pathway and operative technique*

A complete clinical pathway was an integral part of starting the aortic service. One midlevel practitioner (M.S.) assisted the BMC surgeon (D.M.) on all aspects of the aortic clinic and surgery. Patients referred to this service have an initial consult and are counselled on aortic aneurysms or other pathology for which they were referred. The patient's aortic disease is then broadly classified as sporadic, degenerative, syndromic or familial. In cases of suspected hereditary aortic disease, patients' family members are also urged to undergo screening. All patients are screened for multiple aneurysms and undergo lifelong monitoring before and after surgical treatment. Patients with less severe disease and those who are unfit for surgery are also followed long-term. Based on each patient's needs and the extent of disease, a course of intervention is chosen as either medical treatment with β blockers[17,18] and angiotensin converting enzyme inhibitors[19] or surgical treatment, when required. Aneurysms and intramural hematomas distal to the aortic arch were evaluated with an intention to treat by endovascular means as a first choice. In the thoracic aorta, ideal candidates had ulcers with large intramural hematoma or a saccular aneurysm. In the abdominal aorta, ideal candidates had an infrarenal aneurysm with an adequate neck. In all cases, we looked for a 20 mm proximal and distal seal. All borderline cases were reviewed with HUP surgeons using web-based image sharing. A representative from the graft vendor brought in the stent grafts on a per case basis and was present as a resource throughout the operative procedure.

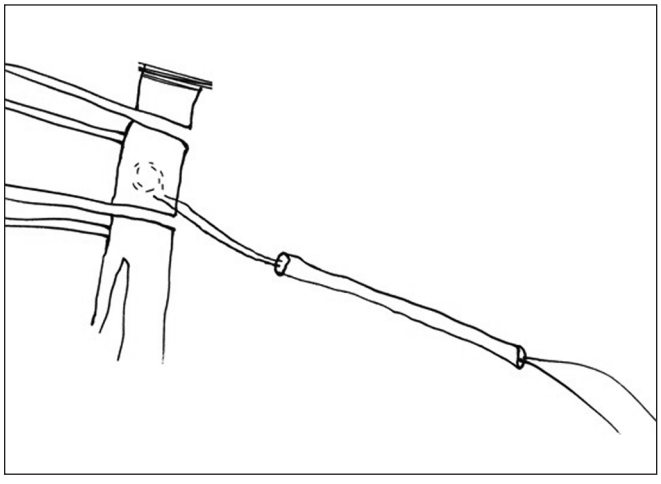

**Fig. 2.** The femoral artery entry site is encircled with a double purse string using a single suture. The first layer is in the media, while the second layer is in the overlying adventitia. The entry site can be controlled by applying gentle traction on the suture. It can be secured with a clamp applied to the tourniquet when it is pushed against the entry site.

Prior to surgical treatment, preoperative evaluation for all patients included echocardiography, nuclear medicine–based stress testing and anesthesia consultation. Patients were admitted on the day of surgery and acetylsalicylic acid and β blockers were continued perioperatively. The EVAR procedures were carried out with bilateral open common femoral artery access. The EVAR planning was done preoperatively using 3D image processing to evaluate the aneurysm as well as iliac and femoral access size. All patients received general anesthesia and underwent comparison of upper body and lower extremity arterial line tracing after repair of femoral artery access. The TEVARS were carried out with unilateral open femoral or common iliac artery access and contralateral percutaneous access. Depending on the degree of calcification, superficial femoral artery access was occasionally preferred. In all cases, a purse string suture consisting of 4–0 polypropylene with a small red tourniquet was used to encircle the entry site (Fig. 2). This minimized blood loss and permitted downsizing access when exchanging the delivery system sheath for a moulding balloon access sheath. The purse string suture is removed at the end of the operation and the femoral artery is repaired with interrupted 5–0 polypropylene sutures. All cases were completed using Cook Zenith (Cook Medical) or Endurant (Medtronic) graft systems. Postoperatively, all patients went to the cardiovascular surgical care unit, which has the ability to list patients as intensive, intermediate or surgical care. Patients could be discharged home or to a rehabilitation facility from the unit without first going to a different hospital. Follow-up CTA with 2- and 5-minute delay films were obtained 4–8 weeks postoperatively and at 6–12 month

intervals thereafter. Ultrasonography was used selectively to monitor aneurysm sac size when appropriate to decrease the risk of radiation exposure.[20,21]

### *Community awareness*

To increase awareness of the new endovascular service, we used a variety of outreach programs. These included mass mailings, meet and greet lunches with primary care physicians and senior citizen education at community centres. Special emphasis was placed on the importance of aortic aneurysm screening for high-risk patients. Patient recruitment increased community awareness about the dangers of aortic aneurysm, the benefits of early detection, and possible options for AAA repair.

### *Statistical analysis*

Data were collected and analyzed with Microsoft Excel 2010. We compared continuous variables using a Student *t* test, when appropriate.

## Results

In all, 160 patients in the BMC aortic clinic were evaluated and followed for a total of 176 aortic pathologies over 46 months. Of these pathologies, 155 were aneurysms. Table 2 shows the anatomic distribution of these 155 aneurysms and the average age of the corresponding

**Table 2. Number of patients evaluated for aortic aneurysm pathology, *n* = 155**

| Pathology | No. patients (male) | Age, median (range) yr |
|---|---|---|
| Thoracic | | |
| TAA ascending | 55 (42) | 66 (47–88) |
| TAAA descending | 8 (3) | 67 (47–76) |
| Type I/II TAAA | 2 (1) | 66.5 (66–67) |
| Abdominal | | |
| AAA | 79 (62) | 75 (51–90) |
| Type III TAAA | 6 (2) | 65 (60–77) |
| Type IV TAAA | 5 (0) | 73 (66–73) |

AAA = abdominal aortic aneurysm; TAA = thoracic aortic aneurysm; TAAA = thoracoabdominal aortic aneurysm.

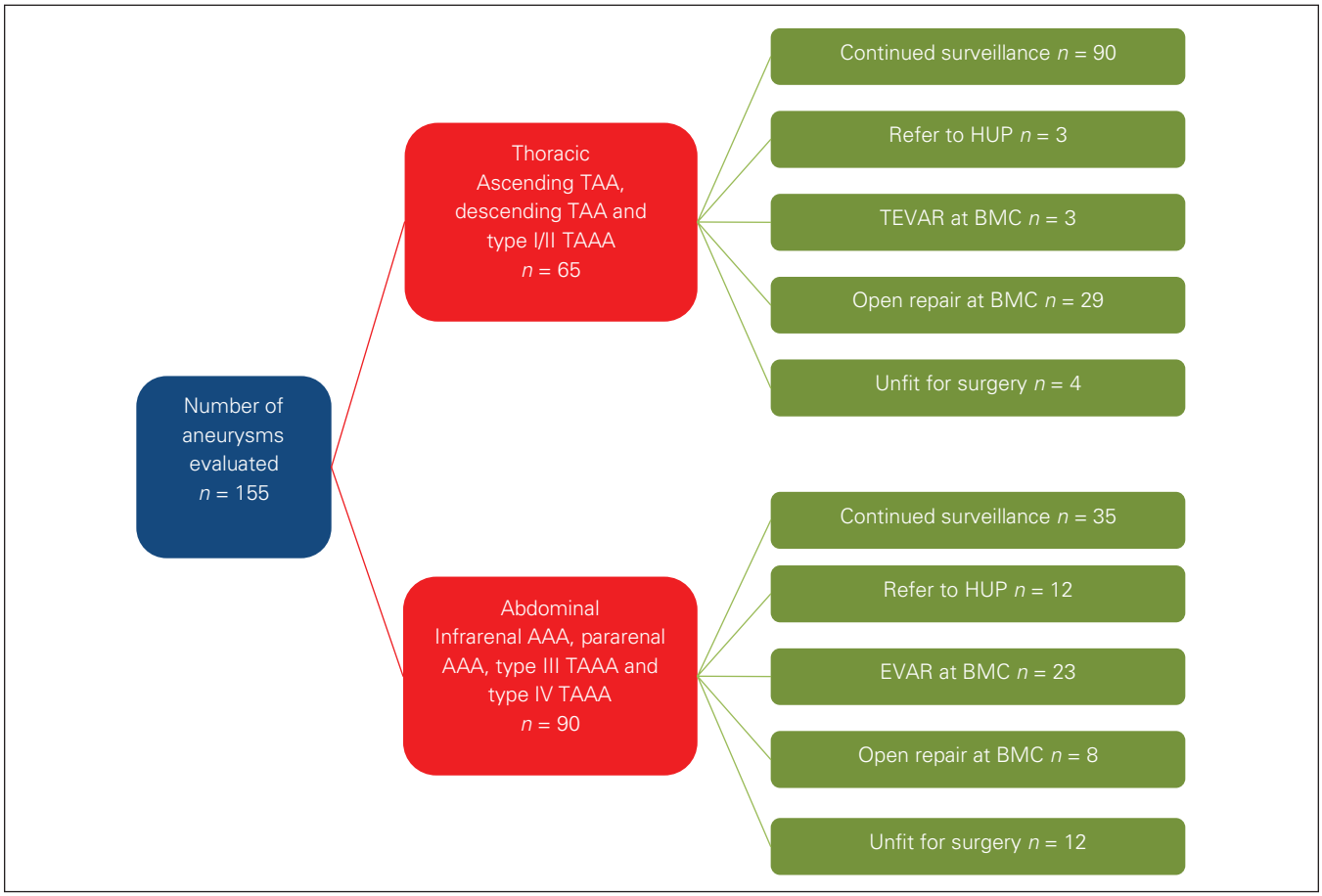


**Fig. 3.** Patients evaluated and treated in the aortic clinic at Bayhealth Medical Center (BMC). AAA = abdominal aortic aneurysm; EVAR = endovascular aortic aneurysm repair; HUP = Hospital of the University of Pennsylvania; TAA = thoracic aortic aneurysm; TAAA = thoracoabdominal aortic aneurysm; TEVAR = thoracic endovascular aortic aneurysm repair.

patients. Other pathologies included dissection, intramural hematoma and mesenteric ischemia. Figure 3 shows the number of patients evaluated for aneurysm surgery who had open repair, had endovascular repair, were referred to HUP or underwent further surveillance. Of the 90 abdominal aortic pathologies, 23 were treated with EVAR and 8 were treated with open repair. Of the 65 thoracic aortic pathologies, 3 were treated with TEVAR and 29 were treated with open repair.

Overall, 9.7% of pathologies (15 of 155) were referred to HUP for treatment. Two of these were for persistent endoleaks and growing aneurysm sacs in patients previously treated with EVAR at other hospitals. In total, 49.7% of evaluated aortic pathologies (77 of 155) underwent further surveillance, with 16 of these patients deemed unsuitable for EVAR or open repair. Many of these patients had advanced frailty or dementia.

A total of 23 EVAR and 3 TEVAR procedures were carried out at BMC. None was emergent. Iliac artery access was required in 4 cases because of small femoral artery size. One patient with an aortoiliac aneurysm required hypogastric artery coiling, which was performed by an interventional cardiologist 1 week before surgery. Table 3 shows the results of endovascular and open abdominal aortic aneurysm repair at BMC during the study period. All 8 open abdominal procedures involved a retroperitoneal approach with suprarenal or supraceliac clamping. Three were for the diagnosis of type III ($n$ = 2) or IV ($n$ = 1) thoracoabdominal aortic aneurysms (TAAA). These patients were treated with adjunct distal perfusion, when appropriate. In this study, perioperative morbidities were considered separate from endoleaks. The mean size of aneurysms operated on for both EVAR and open repair was comparable (mean 5.6 ± 0.8 cm v. 5.6 ± 0.9 cm; $p$ = 0.97) and there was no significant difference in the average age of patients who underwent each procedure (mean 71.7 ± 9.0 yr v. 74.4 ± 7.7 yr, $p$ = 0.46). The length of stay in hospital of patients undergoing EVAR was significantly shorter than that of patients undergoing open repair (mean 3.0 ± 1.3 d v. 9.8 ± 3.8 d, $p$ = 0.002). There were no conversions to open surgery during the study period. Vascular morbidities are summarized in Table 4. Two patients required femorofemoral bypass perioperatively. In 1 case, this was because of the inability to cannulate the contralateral main body gate, causing conversion to a uni-iliac stent graft repair. In another, it was because of iliac artery stenosis that was aggravated by the stent graft. Three patients required iliac artery angioplasty, 2 of which included stent placement. There were no perioperative deaths in both EVAR and open repair groups. Instances of perioperative morbidity occurred in 4 of 23 EVAR repairs, including a patient with a postoperative ileus, a patient in whom renal dysfunction developed because pre-existing artery stenosis became occluded due to plaque shift, a patient with graft infection and a patient in whom a GI bleed developed 2 weeks postoperatively due to clopidogrel being taken for a previous carotid artery stent. The graft infection required excision and extra-anatomical reconstruction after referral to HUP. A pre-existing aortoduodenal fistula was suspected. Perioperative morbidity occurred in 2 of 8 open repairs, including a patient who experienced renal dysfunction and another patient who experienced dialysis-dependent renal failure. The latter patient had a pararenal abdominal aortic aneurysm. There were no perioperative deaths or morbidities in the TEVAR group.

Endoleaks were classified as types I, II or III. These represent seal area, retrograde fill and graft overlap area leaks, respectively. Reintervention for endoleak was required within 30 days in 2 patients. One, a type I, was post-TEVAR and presented with sudden back pain before discharge. The other, a type III, was post-EVAR and presented with paroxysmal tachycardia and mild anemia before discharge. Both patients underwent uneventful reintervention with additional stent graft placement. Five patients had type II endoleaks. Late type III endoleaks were suspected in another 2 EVAR patients, but these were not confirmed by brachial accress angiograms, and there has been no sac growth on follow-up imaging to date. One TEVAR patient had a late aortic dissection distal to the graft within 1 year of treatment.

No patient in this series required reintervention for late endoleaks to date. Type II endoleaks are evaluated with serial CTA and managed conservatively as long as the aneurysm sac size is stable or shrinking. Complex type II leaks that seem progressive or that could be confused with type III leaks were reviewed with a university surgeon.

**Table 3. Results of abdominal aneurysm repair**

| Procedure | Aneurysm size, mean ± SD, cm | Age, mean ± SD, yr | No. patients (male) | LOS, mean ± SD, d | Perioperative morbidity* | Follow-up time, median (range) mo |
|---|---|---|---|---|---|---|
| EVAR, $n$ = 23 | 5.6 ± 0.8 | 71.7 ± 9.0 | 23 (17) | 3.0 ± 1.3 | 4† | 6.7 (1.0–22.7) |
| Open repair, $n$ = 8 | 5.6 ± 0.9 | 74.4 ± 7.7 | 8 (4) | 9.8 ± 3.8 | 2‡ | 4.0 (1.7–37.6) |

EVAR = endovascular aortic aneurysm repair; LOS = length of stay; SD = standard deviation.
*There were no deaths. Endoleaks were considered separately from perioperative morbidities.
†The instances of morbidity include a patient with a postoperative ileus, a patient with renal dysfunction due to plaque shift, a patient with graft infection and a patient with a gastrointestinal bleed 2 weeks postoperatively due to clopidogrel being taken for a previous carotid artery stent.
‡One patient had renal dysfunction while another patient had dialysis-dependent renal failure postoperatively.

## Discussion

The BMC created its heart program because of a need to serve a growing regional population in the range of 250 000–500 000. Until we initiated this program, abdominal aneurysm care was provided by the general surgeons. Patients underwent open repair or were referred for endovascular stent grafting. The local interventional cardiologists serve most of the peripheral vascular needs for the community. The local general surgeons treat the remaining patients who require open surgery for peripheral arterial or venous pathology, including emergent thromboembolectomy and femorofemoral bypass of the lower extremity. There is no local vascular surgeon. The BMC endoaortic program was established by a cardiac surgeon. However, the present model could be established by a general or older vascular surgeon willing to undergo training and credentialing, as described in the Methods section. In addition, the model we describe for a comprehensive aortic clinic can be used by a vascular surgeon wishing to partner with a distant university program. Clearly, hospital or health system support is required to ensure that incentives and goals of all parties involved are aligned. The purpose of this article was to describe how a region that was underserved for aortic care could become partially or mostly served locally. We noted that more than 80%–90% of the pathology we evaluated was aneurysmal disease.

The majority of patients requiring endovascular treatment had infrarenal AAAs. There were no conversions to open surgery, reflecting careful patient selection. Initially, almost all cases were reviewed with the university surgeons preoperatively. With time this proportion fell to about 1 in 4. Adjunct surgical procedures commonly used were femoral artery exposure, iliac artery exposure via the retroperitoneum and femorofemoral bypass. Along with catheter and wire skills, such procedures can be performed by general surgeons willing to undergo a short training period. The cognitive requirements for clinical evaluation and follow-up are also within the reach of the general surgery knowledge base. Most abdominal aortic aneurysms are currently treated by endovascular repair, which has less perioperative morbidity and shorter hospital stay.[7–9] Open aneurysm cases have more complex neck anatomy and may require referral to a university centre, depending on the local surgery team. At BMC, this was not always necessary, as the surgeon (D.M.) had previous experience with retroperitoneal exposures, which is more commonly needed with complex neck anatomy.

**Table 4. Vascular morbidities for EVAR (*n* = 23) or TEVAR (*n* = 3)**

| Vascular comorbidity | No. |
|---|---|
| Femorofemoral bypass | 2 |
| Early type I endoleak | 1 |
| Early type III endoleak | 1 |
| Type II endoleak | 5 |
| Undetermined endoleak | 2 |
| Late type B aortic dissection | 1 |

EVAR = endovascular aortic aneurysm repair; TEVAR = thoracic endovascular aortic aneurysm repair.

The initial results of this small data set show that, through collaboration with a university hospital, starting such a program at a rural regional medical centre can be successful. The results of AAA repair by both endovascular and open means at BMC are similar to results reported in major studies and reviews.[7–11] The patient population for our study was similar to that in these trials. These studies report 30-day mortality of 0.5%–1.2% for endovascular repair and 3.0%–4.8% for open repair. Although the operative mortality at BMC (0% for both endovascular and open repair) was lower than these findings, this could be because of our relatively small number of procedures as well as our affiliation with a major university centre, which tends to take on our higher-risk or atypical anatomy patients. For our study, the mean length of stay in hospital for endovascular and open repairs was also similar to that of other studies.[7–11] The rate of morbidities and endoleaks in our study was similar to results of these other trials.

To date, reintervention was required in 3 of 26 (11.5%) endoaortic procedures. These were early reinterventions, and there have been no late reinterventions to date. This could be because of the use of newer generation stent grafts, which have improved fixation. We also found that as our experience grew we became more comfortable with iliac artery stent angioplasty to treat residual stenosis after EVAR, reducing the risk of unplanned femorofemoral bypass. Similarly we had 1 conversion to uni-iliac repair early in our experience because we could not cannulate the contralateral limb gate. We have since learned to capture a wire from the ipsilateral side with a snare and pull it down through the contralateral gate as an alternative.

Although the endovascular surgery program was created to fill a need, it has led to the creation of an aortic disease clinic. Patients are therefore followed from initial consult to intervention and screened in a lifelong monitoring program. Hopefully this will impact AAA-related mortality in the BMC service area. There have been 160 patients evaluated in the clinic within a 46-month period. This has led to an increased expertise in imaging of aortic pathologies and collaboration with local radiologists. It was necessary to use many imaging modalities, depending on purpose of the imaging study. For example, noncontrast CT or magnetic resonance angiography (MRA) studies were used mainly for aneurysm screening and monitoring and contrast-enhanced CT studies with 3D image reconstruction were used for all patients needing surgery.

We tried to base our approach to patient selection on guidelines as well as common community practice. In the case of thoracic aortic aneurysms, this meant limiting our

selection to intamural hematoma with ulcer or saccular aneurysm. Our series included 1 of each and 1 reintervention, as noted previously. More complex or trauma cases were referred to the university centre for enrolment in trials or received surgery via a conventional open approach. This was in keeping with the 2010 American Heart Association guidelines on thoracic aortic disease.[22] In the case of abdominal aortic aneurysms our patients usually had the expectation of endovascular repair. Randomized trials have demonstrated the safety of EVAR versus open repairs with lower early mortality, but some of the data remain controversial as to overall superiority in patients younger than 65 years.[8,11] Our patient selection (average age 71.7 yr) was in keeping with this as well as the 2009 Society of Vascular Surgery guidelines.[20] More than half the abdominal aneurysm repairs in the United States are currently treated by endovascular means. This trend has been correlated with the observation that the number of annual deaths from intact and ruptured AAA has substantially decreased in the United States. This has coincided with an increase in elective AAA repair after the introduction of EVAR and a decrease in the diagnosis and repair of ruptured AAA.[6] The question of treating infrarenal aneurysms with contained ruptures merits consideration. In our hospital, such patients are treated by the on-call general surgeon with an open operation or are referred. As we gain experience and as newer generation ruptured aneurysm uni-iliac kits become available, it may be possible for our centre to offer emergent EVAR to such patients. The limitation that we face is that it is not cost-effective for a small program to stock stent grafts in all sizes locally. A vendor representative must be brought in for every case at this stage. We have been able to offer urgent EVAR (within several days) for symptomatic aneurysms. We also found that there are fewer TEVAR operations needed than EVARs. Our hospital is unique since we have perfusion services to back up TEVAR procedures should open conversion be needed. Even with such backup available, we carefully select only the most simple TEVAR operations, typically intramural hematoma or saccular anurysms meeting criteria for intervention. It can be expected that many similar sized centres would not have such a service and would be referring TEVARs to the university centre. Such patients could still be followed in a local aortic clinic. This illustrates the notion that a comprehensive aortic clinic that partners with a university centre is preferable.

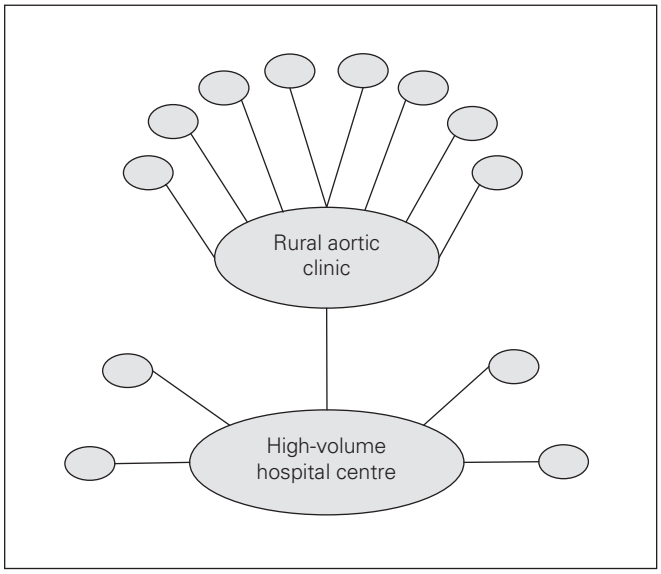


**Fig. 4.** Illustration of the double "hub-and-spoke" model. The rural aortic clinic acts as a weigh station for patients with aortic pathologies. Patients of all local providers can be treated locally or referred to the high-volume hospital centre in a streamlined process. Local providers are served by a single, local aortic clinic.

Some reports suggest that many rural centres refer their aortic aneurysm cases to high-volume, urban centres.[5,13,14] However, it has been shown that patients prefer to see physicians closer to home, despite a possibly higher mortality.[23] Primary care physicians may also wish to refer patients to specialists based on qualities such as appointment timeliness and communication.[24] There is a possibility that rural patients are underserved by urban centres despite idealistic intentions. We overcame these obstacles through the use of a "hub-and-spoke" model in which patients are able to access a single, local aortic clinic. Patients at the clinic are either referred to the high-volume university centre or treated and followed locally. In cases where patients require referral, they are counselled locally. Their films are prereviewed by the university surgeon and discussed with the local surgeon. The local surgeon can communicate with local primary care physicians and provide follow-up after surgery for the university centre. Also, in this way, referrals are screened for fitness for surgery before being seen at the university centre, preventing patients from travelling unnecessarily. Cardiology clearance is obtained locally before referral by the comprehensive aortic clinic, assisting the local primary care physician with this potentially complex decision tree. This model is also advantageous for the high-volume university centre. Treatment is streamlined because patients are essentially ready for surgery when they are seen by accepting surgeons. The "hub-and-spoke" model described here is really a double "hub-and-spoke" model and is illustrated in Figure 4.

Other literature describes the introduction of an endovascular aortic surgery program into a nonuniversity hospital using vascular surgeons and interventional radiologists.[25] In our model, a surgeon spent 3 days per week over a 6-month period at the university hospital. This allowed the surgeon to receive the necessary training and experience without unacceptably disrupting local services. The BMC nursing and endovascular team also travelled to HUP to observe cases intermittently. This was then crystallized by having a HUP surgeon proctor the BMC team for its first 5 cases and sign off on their competency. Credentialing

policies must be set by the appropriate hospital committee using nationally recognized guidelines. In our case, we set the bar fairly high for initial credentialing. Recredentialing guidelines are not as well defined. Our team found that trying to do at least 1 case per month was a comfortable pace for familiarity. As patient load grew, the comprehensive approach we strived for required additional personnel, such as a physician assistant or nurse practitioner, to consolidate care and assist in seeing patients.

## Conclusion

Creation of the endovascular aneurysm repair program at BMC allowed for many of the less complicated cases to be treated with EVAR, where they previously would have been treated with open repair or referred. As experience was gained with endovascular procedures, more complex cases were treated at BMC rather than referred to HUP. The collaboration also facilitated BMC patient access to new graft trials at HUP. The BMC gained brand recognition with a renowned medical centre, while the high-volume centre broadened its outreach.

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