PANEL DISCUSSION

Essential Elements of a Comprehensive Aortic Team

Experts share their experience and advice for creating top-flight aortic teams, training juniors, being prepared for aortic emergencies, and ensuring safety for patients and operators.

With Ali Azizzadeh, MD, FACS; Kendal Endicott, MD; Javairiah Fatima, MD, FACS, RPVI, DFSVS; Ross Milner, MD, FACS; and Brant W. Ullery, MD, MBA, FACS, FSVS

Ali Azizzadeh, MD, FACS
Professor and Director, Division of Vascular Surgery
Vice Chair, Department of Surgery
Associate Director, Smidt Heart Institute
Associate Dean, Faculty Affairs
Cedars-Sinai Medical Center
Los Angeles, California
ali.azizzadeh@cshs.org

Kendal Endicott, MD
Inova Health Systems
Inova Heart and Vascular Institute
Co-Director of the Inova Heart and Vascular Complex Aortic Program
Assistant Professor of Surgery, Uniformed Services of the Health Sciences (USUHS)
Assistant Professor of Medical Education, University of Virginia Health System
Falls Church, Virginia
kendal.endicott@inova.org

Javairiah Fatima, MD, FACS, RPVI, DFSVS
Associate Professor of Surgery
Co-Director of the Complex Aortic Center
MedStar Heart and Vascular Institute
MedStar Health, Georgetown University
Washington, DC
javairiah.fatima@medstar.net

Ross Milner, MD, FACS
Chief & Professor of Surgery, Section of Vascular and Endovascular Therapy
Vice-Chair, Clinical Affairs and Perioperative Services
Codirector, Center for Aortic Diseases
The University of Chicago Medicine
Chicago, Illinois
rmilner@surgery.bsd.uchicago.edu

Brant W. Ullery, MD, MBA, FACS, FSVS
Medical Director, Vascular and Endovascular Surgery
Providence Heart and Vascular Institute
Portland, Oregon
brant.ullery@providence.org

In general, what staff positions comprise a top-flight aortic team?

Dr. Azizzadeh: Comprehensive aortic teams need to be able to perform the full spectrum of open and endovascular procedures. This often requires collaborative teams made up of both vascular and cardiac surgeons. In some centers, interventional cardiologists and radiologists also play a strong role. Furthermore, a top-flight aortic team requires multiple layers of support that go beyond the surgical team.

Dr. Ullery: Although there may be some local institutional nuances, a top aortic team requires a multitude of key stakeholders: endovascularly trained cardiac and vascular surgeons, anesthesiologists, critical care nurses and physicians, emergency department (ED) physicians, radiology staff, blood bank, chaplain, and transfer center. In addition, administrative support is essential to ensure strategic alignment, given the resource intensiveness and acuity of aortic patients. I would also highlight that a comprehensive aortic team requires establishment of protocol that enables safe, reliable, and rapid acquisition of lumbar drainage, if needed, by anesthesiologists, neurosurgeons, or intensivists.

Dr. Milner: A top-flight aortic team requires team members from many different specialties. Vascular surgeons and cardiac surgeons are at the core of our team. We have amazing support from nurses (we have a dedicated aortic nurse), advanced practice providers (APPs), intensive care unit (ICU) staff, anesthesiologists, and interventional cardiologists. We function as a collaborative unit and have a frequent multidisciplinary aortic conference and combined outpatient clinics.

Dr. Endicott: The most important aspect of optimizing aortic care is harnessing the most experienced, talented, and invested personnel in your hospital. At our institution, this involves cardiac surgery, interventional radiology, and vascular surgery. Particularly in the treatment of complex aortic pathology including dissections, multidisciplinary relationships are essential. A close relationship with the ICU to maximize preoperative and postoperative care can also optimize patient outcomes.

Dr. Fatima: An aortic team is a multidisciplinary team that is led by an aortic surgeon and includes cardiovascular anesthesiologists for perioperative management and cardiovascular intensivists with an ICU setup to manage these complex patients postoperatively. A dedicated surgical operating room (OR) team who are well-versed and trained in open and endovascular aortic procedures are essential for procedural success and ultimately optimizing patient outcomes. As an aortic center is typically involved with significant research component as well, especially if an investigational device exemption is part of the program, dedicated research coordinator(s), an aortic clinical coordinator, a monitor, and a project manager are critical positions to ensure a successful program.

Which intrahospital relationships are essential, and how are these connections made and maintained? What about with outside referrers?

Dr. Endicott: We have established strong multidisciplinary relationships among our hospital departments. We meet for aortic conference to review preoperative cases twice monthly. We also participate in limb salvage conferences monthly. These relationships are further fostered in joint limb salvage, venous, and aortic cases. In addition, the creation of an aortic clinic with multidisciplinary participation is underway to help guide referring physicians.

Dr. Fatima: It is vital in today's era for vascular surgeons and cardiac surgeons to run the aortic center in conjunction with each other as one team. This facilitates appropriate patient selection for complex arch and thoracoabdominal aortic aneurysms (TAAAs). A team approach allows tailoring the best treatment for each individual patient, whether it is open, endovascular, or a hybrid approach. We are fortunate to have great camaraderie with our cardiac surgeons and review mutual patients at system-wide aortic conferences and/or in clinic or inpatient setting.

Strong partnership with cardiology is important for optimizing patients preoperatively, as well as with cardiovascular anesthesiologists to assist with perioperative and intraoperative management of adjunctive therapies to reduce the risk of spinal cord ischemia. Use of spinal drains is an integral part of complex aortic procedures and cardiovascular anesthesiologist or a neurosurgeon needs to be available for placement or troubleshooting these drains at all hours of the day. These relationships are built through good communication, setting expectations, and routinely evaluating the systems in place at scheduled intervals to troubleshoot any pitfalls and maintain open lines of communication for system improvements.

From a referral standpoint, it serves one well to participate in grand rounds and teaching endeavors for different service lines, such as internal medicine, family medicine, radiology, emergency medicine to educate the faculty and residents. This helps with inpatient referrals and outpatient screening and referrals in a timely man-

ner. Regular follow-up to referring providers via sharing images, outcomes, plans, and follow-ups helps build and maintain these relationships.

Dr. Azizzadeh: Some of these supportive elements include anesthesia, nursing, OR technicians, perfusion, allied health professionals, critical care, pathology/blood bank, and consulting services such as critical care, cardiology, pulmonary, radiology, and nephrology. Other supporting services including nutrition, pain management, physical and occupational therapy, and social work play a key role in the full recovery of the patients. Having a dedicated ICU and ward staff trained to take care of cardiovascular patients is essential.

Close collaborative relationships with outside referring doctors is also essential. Many of our patients are referred by practicing community surgeons who are very capable. They recognize that successful outcomes in some challenging patient populations depend on multiple factors that go beyond the surgeon's skill set. The infrastructure and support systems present in quaternary referral centers are crucial to improving outcomes.

Dr. Milner: The relationships are critical, and the relationships within our institution are relatively easy. We have a group of providers who want to provide patients with the most outstanding care for aortic disease, aneurysms, and dissections. We commonly discuss the options of open surgery, endovascular repair, and hybrid approaches. We decide what is best for the individual patient given their risk profile and anatomy.

Outside referrals are a large source of our volume. We commonly transfer patients that require emergency care for aortic dissections from surrounding institutions. In addition, our elective referral practice is busy as we offer unique options to treat complicated patients.

Dr. Ullery: Although all stakeholders are clearly valuable, I have found greatest value in developing and maintaining strong relationships with our transfer center and intensivists. Bed capacity and resource constraints continue to plague our health care system now more than ever. As such, ensuring all of our partnering care team members, especially the transfer center and intensivists, buy into our institutional "must-take" philosophy for patients with acute aortic syndromes is paramount. Regardless of census, staffing challenges, or preexisting transfer wait lists, we always find a way to accept and facilitate rapid transport of these patients. These relationships are developed and maintained by keeping all stakeholders engaged with the status of the patient at all stages of the patient care journey. For instance, our surgeons are in regular communication with the transfer center after initial acceptance of these patients to confirm estimated time of arrival to our facility, facilitate timely communication with referring physicians, and confirm receipt of radiographic images before the patient arrives. Our surgeons also actively involve the ICU immediately to ensure appropriate seasoned nursing staff are available for intensive perioperative management. Once the patient arrives and the aortic intervention is complete, our vascular team remains involved in all aspects of care, including coordination across specialties, such as infectious disease, nephrology, and interventional radiology. This investment, including calling the transfer center personnel and referring ED providers in real time after the operation to express gratitude for their efforts and offer insight as to how the procedure went, has offered additional benefits as it pertains to facilitating a constructive quality review process and ongoing educational in-services.

How many device platforms should an aortic team have facility with, and how many different options should realistically be on one team's shelf? How does your team stay up to date with new aortic technologies as they enter the market?

Dr. Fatima: Each device platform has unique features that allow them to be best suited for specific individual anatomies. Although it may be ideal to have access to all devices, an aortic center should have at least two to three different devices with multiple available sizes on the shelf to address urgent and emergent cases as well. In line with this, we have at least two different endovascular aneurysm repair (EVAR) and thoracic endovascular aortic repair (TEVAR) devices in all available sizes readily available on the shelf and select (commonly used) sizes for other platforms also readily available in-house. We are involved with most aortic device clinical trials, which allows us access to the more complex aortic repairs, including the arch as well as TAAA, and helps with easy transition as they become commercially available.

Dr. Milner: I do not think there is a specific number of platforms that one team should have available. It is worthwhile to use different platforms so that you can select the best option for a specific patient. We most commonly use two technologies but do not limit our practice to those platforms only.

We are fortunate that we are frequently involved in clinical trial work. Thus, we can stay up to date. In addition, we attend national and international conferences to see new technology that we can adopt.

Dr. Endicott: Every device is different with advantages and disadvantages relative to the patient's anatomy. The best-equipped aortic teams are facile with all devices. Although all treatment options should be available on an elective basis, our institution supports two on-the-shelf EVAR devices for emergencies, including an aorto-uni-iliac device and one thoracic EVAR option.

Staying up to date on new technology develops naturally out of an ongoing partnership with industry to develop the best endovascular solutions for our patients. Participating in device trials provides an easy way to actively participate in advancing new devices to market and stay current on the latest advances.

Dr. Ullery: In the spirit of customizing endovascular solutions to the specific anatomy (as opposed to simply fitting any anatomy to a preferred device platform), I would recommend familiarity with at least two or three device platforms across both the thoracic and abdominal aorta. This will allow operators to understand and better appreciate the strengths and limitations of each device platform, a foundational understanding that guides rapid device selection and case planning in urgent/emergent cases. Moreover, certain device platforms are more conducive to off-label adjunctive techniques, if necessary. That said, on-shelf availability of one or more device manufacturers will no doubt be institutionally dependent based on local historical practices, vendor contracts, and clinical volumes. If institutional volume is low, a single preferred device manufacturer may suffice given that the majority of aortic pathologies can be treated successfully with most platforms and the threshold to transfer to a tertiary/quaternary center is lower for more complex cases. However, higher-volume programs are more likely to see the full myriad of anatomic complexities (eg, iliofemoral access challenges, hostile necks) and higher percentage of urgent/emergent cases. This would support on-shelf availability of at least two complementary abdominal and thoracic aortic device platforms to maximize on-label anatomic suitability for aortic endografts.

As we are part of a large integrated health system, obtaining access to new aortic technologies can be a struggle that has only been exacerbated in recent years given the financial climate. New product requests in our system prioritize those devices that expand treatment options, provide an improved safety profile, or offer cost savings relative to existing competitors. Our team remains committed to staying up to date with new technologies by engaging with industry and colleagues at regional and national meetings, staying current with academic literature, and regularly challenging the status quo at our multidisciplinary aortic care conferences.

Dr. Azizzadeh: Having access to multiple device platforms enables surgeons to optimally tailor the treatment plan to the anatomy and physiology of a specific patient. To address emergency acute aortic syndrome patients, a full inventory of aortic devices on the shelf is essential. We participate in investigational device trials to enable our patients to have access to the latest technology. This allows our teams to accumulate experience with devices in the pipeline before FDA approval.

What do you feel are the essential steps in training juniors to technical proficiency and mastery of endovascular techniques?

Dr. Ullery: This is an important question. Like most surgeries, the majority of the work in these cases centers on preparation and associated detailed case planning. I am a strong believer that all operators should have a working knowledge of the entire competitive landscape in endovascular aortic surgery, as this promotes the philosophy of fitting the correct device/technique to the correct anatomy (as opposed to fitting all anatomies to one specific device or technique). It is a good exercise for all endovascular surgeons, regardless of stage of training, to devise several potential case plans using a variety of techniques and, at times, even widely different device manufacturers. This will objectively highlight the advantages and disadvantages of each case plan, thereby facilitating a final decision for the most optimal treatment strategy. Moreover, I find that this deliberate approach forces one to constantly reevaluate and challenge our inherent practice biases and preferences.

Dr. Milner: Preparing for high patient volume is essential; a busy center can expose trainees to standard and complex endovascular techniques. In addition, more than one busy surgeon is valuable to provide access to different treatment paradigms so that residents and fellows can learn options. I think technical proficiency is gained as learners plan cases, prepare for unexpected outcomes, and have a backup plan for when plan A is not working as expected.

Dr. Azizzadeh: There is no substitute for surgical experience. My advice to trainees is to enlist in training programs that have a robust clinical volume and perform the full breadth of open and endovascular procedures. Training courses and simulators are also a great to supplement a diverse training program.

Dr. Fatima: An apprenticeship model is beneficial for junior partners if they have vested interest in pursuing a career as an aortic surgeon. Endovascular surgery has

multiple key components, including planning, sizing, in-depth discussion with patients and setting expectations, technical execution in the OR per plan A, while being ready to switch to plan B, C, D, or E as needed. With endovascular procedures, a very large part of the procedure is done preoperatively in the planning phase. A poor plan even in the best of hands is bound to fail. Therefore, training for juniors should have huge emphasis on learning how to plan well. Double scrubbing in the OR with a seasoned aortic surgeon helps one to learn tips, tricks, and bailouts while gaining self-confidence and experience. If pioneering such practice at your institution, it is advisable to seek mentorship with an aortic expert nationally or internationally and consider doing a dedicated aortic fellowship. Finally, following these patients and studying their follow-up imaging in detail helps one to obtain an in-depth understanding of what works and what does not, modes of failure, and helps one mature as a surgeon.

Dr. Endicott: My approach toward teaching endovascular surgery is to focus first on how to "think endo." Emphasis should be placed on preoperative planning, anticipating pitfalls, and preparing for plans B, C, and sometimes D. Mastery of techniques in endovascular procedures comes with time and repetition.

How do you keep your trainees facile with open procedures in an era in which endovascular care is prevalent?

Dr. Azizzadeh: When I went through training, finding a program that offered advanced endovascular experience was desirable. Today, the pendulum has swung in the opposite direction. There are still many programs, including ours, that offer plenty of open experience. The key is to have a balanced training so future surgeons can offer the correct therapy to patients with equipoise.

Dr. Fatima: In my practice, we aggressively push the endovascular approach for older or frail patients when their physiology is not conducive to open repair; however, young and healthy patients who are not well within the instructions for use for endovascular approach or have any hostile feature are offered open aortic repair. It is not uncommon for trainees in my program to double scrub with their senior resident on these procedures. Other opportunities for learning aortic exposure is by facilitating trainees to scrub in on spine exposure cases.

Dr. Ullery: The overwhelming majority of open aortic surgeries in our practice are complex, indicating that they have either failed endovascular treatment (eg, refractory endoleak), possess challenging anatomy not amenable to conventional or even off-label endovascular therapies, or, alternatively, have known or suspected connective tissue disease where endovascular surgery is deemed not appropriate by multidisciplinary consensus. All cases, both open and endovascular, are deliberate in their case planning. Both the complexity and relative rarity of these open cases warrant multiple surgeons to participate in the intraoperative care of these patients to ensure optimization of overall surgeon experience and operative efficiency. Moreover, all open cases are vetted in our multidisciplinary aortic care conferences to ensure appropriate case selection, preoperative preparation, and availability of optimal staffing.

Dr. Endicott: This is one of the most challenging aspects of training residents and fellows in today's heavily endovascular world. Spending intentional time before the OR to ensure that residents understand operative exposures can maximize experience in the OR. Use of simulation and cadaveric models can also add tremendously to resident education in an era when open surgery is often not first line.

Dr. Milner: I think this is one of our biggest challenges in vascular surgery training today. We are fortunate that we still perform a reasonable amount of open surgery at our institution. The challenge is that much of that open surgery is done for patients who are not suitable for an endovascular approach. Additionally, we attempt to make sure that the experience is evenly distributed to our trainees.

The need for long-term follow-up is increasingly focal in the discussion surrounding EVAR. Who handles patient communications regarding follow-up, and how does your group work to ensure patients return on schedule?

Dr. Endicott: Long-term follow-up is the most challenging aspect of endovascular aortic care. Communication is managed in our office by a dedicated advanced practitioner. Our medical assistants help ensure that follow-up CT images are done prior to follow-up visits. Follow-up visits are scheduled in advance, and any missed appointments prompt direct communication with the patients from our office staff. Telemedicine visits have also helped facilitate improved follow-up by allowing patients to obtain follow-up CTs locally, the results of which we discuss via video visit. We also participate in the Vascular Quality Initiative, which is a great way to gauge actual versus perceived success of long-term follow-up.

Dr. Milner: We all think we do follow-up well until we critically look at out-data. We have an outstanding group of APPs who help keep this part of our practice organized. The most important member of our team is a dedicated nurse to our program. The nurse knows the patients and keeps outstanding records on when follow-up is needed or when a patient did not come for follow-up. We would not be as effective as we are without a dedicated nurse in the aortic program.

Dr. Azizzadeh: We are extremely fortunate to have an outstanding team of patient services representatives who along with our allied health providers help us run the outpatient clinics for our group. We have instituted follow-up algorithms for every procedure. Once a patient has a procedure, our team schedules their follow-up clinic visits along with their surveillance imaging protocol. Occasionally, we will alter our standard protocols as needed based on advice from the FDA or device manufacturers.

Dr. Ullery: Increasing long-term data have highlighted multiple failure modes of conventional EVARs and, by extension, reinforced the importance of adherence to established societal guidelines surrounding long-term postoperative aortic surveillance. Our surgeons commit to having a detailed discussion with patients and family members both before and immediately after surgery to ensure understanding of these failure modes and rationale for long-term aortic surveillance. Our follow-up surveillance imaging protocol is standardized within our group and closely reflects those of societal standards. Our advanced practice practitioners see these patients longitudinally, and surveillance imaging is always evaluated by the operating surgeon to confirm absence of any radiographic findings that would prompt deviation from the established protocol (eg, migration, new endoleak, sac expansion). As part of our comprehensive aortic program, we review our program's adherence to societal guidelines on aortic surveillance and use these data as a quality measure.

Dr. Fatima: A significant proportion of patients' EVARs fail over several years. This makes long-term follow-up critical to identify these patients and intervene electively before any untoward event occurs, such as rupture. Patients who are enrolled in clinical trials are flagged in their medical chart, and their follow-up is monitored, set up, and tracked by our research coordinators. Patients outside of clinical trial are scheduled by the clinical coordinators upon discharge and at the end of each visit for their subsequent visit. The follow-up orders are placed electronically. Any no-shows are contacted through phone and letters to reschedule.

What is your team's follow-up protocol and timing after EVAR? Have there been in any changes in your processes since the recent communications from FDA regarding the need for long-term surveillance?

Dr. Ullery: Our postoperative radiologic follow-up is consistent with recent Society for Vascular Surgery (SVS) guidelines, including a dedicated contrast-enhanced CT (CTA) within 30 days of the procedure. In the absence of endoleak, aneurysm sac expansion, or device migration, we repeat imaging at 12 months postoperatively using CTA or color duplex ultrasound imaging. Annual duplex surveillance continues after the first year for most cases with acceptable radiologic outcomes. Extra effort is made to obtain initial postoperative imaging prior to discharge for patients with social limitations (eg, difficult access to care), those referred from remote geography, or those treated for urgent/emergent indications. In addition, given increased potential for failure modes, patients with hostile neck feature are commonly imaged using both cross-sectional and duplex imaging modalities, regardless of whether an on- or off-label treatment approach was utilized. We are typically slower to regress to duplex imaging alone in this anatomic population but generally eliminate the need for CTA within 36 months of the procedure so long as the aforementioned criteria are met (eg, absence of sac growth, new endoleak, or migration). We have not significantly changed our protocol based on any FDA communications; however, we do subscribe to the growing appreciation that aneurysm sac regression—rather than simply "lack of sac growth"—should represent a primary therapeutic endpoint for EVAR. As such, we continue to survey patients, particularly closely in the long term, especially those who fail to meet this metric.

Dr. Milner: We have used the same surveillance for a while at our institution. The typical paradigm is initial imaging with a CTA at 30 days. Duplex surveillance is then done annually with a KUB x-ray every other year to evaluate device integrity and assess for any migration. We complete a CTA of the chest/abdomen/pelvis every 5 year to assess for device-related issues and any additional aneurysmal degeneration.

Our paradigm is shifted if there is a type II endoleak. We will scan those patients more frequently to assess for any sac size changes. If there is growth of > 5 mm, we will obtain a CT scan.

Dr. Fatima: Our typical follow-up for endovascular procedures includes CTA at 1, 6, and 12 months, followed by annual CTA. Based on physician/patient preference or in the setting of kidney dysfunction, the CTA can be substituted with noncontrast CT to assess architectural integrity with aortic duplex to evaluate for any endoleaks. For fenestrated/branched EVAR, renal and mesenteric duplex ultrasounds are also performed at the previously described intervals.

Dr. Endicott: We follow the SVS guidelines regarding timing and modality of follow-up imaging. If patients are unable to follow-up long term due to social factors, EVAR is not offered. I think setting expectations starts in the preoperative forum in the office. When discussing open versus endovascular options with a patient, I describe endovascular repair as an easier approach up front, with emphasis on the long-term commitment to ensure aneurysm exclusion. I tell patients that endovascular repair commits them to "being my friend forever."

With regard to recent FDA emphasis on the need for long-term surveillance with certain devices, our surveillance protocols have not changed. In long-term follow-up with patients, we have been transparent regarding the known device failures, and we have emphasized with patients the further need for long-term surveillance.

How does your team maintain preparedness for aortic emergencies such as aneurysm rupture or traumatic injuries? Second, how does communication among the team and with other hospital units such as the ED work?

Dr. Fatima: The aortic team has a call rotation system that facilitates assembling the team as soon as an aortic emergency is posted. A section of the inventory room has all essential supplies of an EVAR and TEVAR labelled and stored to allow for getting the room ready quickly, even by staff who may not be part of the aortic team, and minimize any delays while the aortic team arrives. We have created a direct aortic line for the hospital for all aortic emergencies to be directly routed to a vascular/cardiac surgeon based on the pathology. Flyers are posted with these numbers at various locations throughout the ED. We also conduct grand rounds at intervals to reinforce the protocols and algorithms in place for prioritized transfers and early ED management of acute aortic pathology such as ruptures and dissections.

Dr. Milner: One aspect of our program that I would really like to change is the lack of a dedicated on-call aortic team. We are able to treat most of the traumatic injuries at a time when our team is available and not as an immediate emergency. Ruptures are more challenging. Our industry partners are very helpful with scrub nurses who are less experienced at prepping devices.

Dr. Endicott: All aortic emergencies are transferred in via our transfer center call line. When these calls are received, we have a precise protocol that activates the "aortic team." This alerts the OR team, anesthesia, and the ED of the incoming emergency. Two attending physicians are involved in all acute aortic emergencies, including rupture and aortic transection cases. Cases are performed in our hybrid rooms to allow for endovascular or open treatment as anatomy allows. Standard "rupture" carts are prepared for both endovascular and open cases that are always prepped and ready.

Dr. Ullery: Acute aortic pathologies prompt initiation of our aortic alert system, which provides simultaneous notification to our on-call vascular surgeon, dedicated hybrid OR staff, on-call anesthesiologist, blood bank, ICU, chaplain, radiology department, and ED staff. If the patient is being transported from an outside facility, our transfer center serves multiple critical functions, including ensuring timely physician-to-physician communication with the referring provider, arranging availability of outside imaging studies for surgeons to review prior to transport, and facilitating rapid transport to our site. On arrival to our hospital, these patients are triaged either to the ICU or directly to the OR pending hemodynamic status, goals of care, and availability of preoperative imaging studies. The ED physicians assist us in fast-tracking these patients immediately on arrival should additional cross-sectional imaging be required before definitive repair. To ensure consistent quality control and programmatic refinement, all urgent/emergent aortic cases (including preoperative and postoperative care) are reviewed at our multidisciplinary aortic conferences. Moreover, our surgeons are actively engaged in regular educational in-services with the hybrid OR staff and other partnering service lines to reinforce our acute aortic (rupture) protocol.

Dr. Azizzadeh: Like others, we have a 24/7 transfer center that triages requests from outside hospitals. In addition, we have instituted a 1-888-AORTA11 number for referring physicians.

We have an open line of communication between the ED and the on-call aortic team members. The on-call surgeon directly activates the emergency OR or ICU teams needed to care for the aortic emergency.

Ensuring radiation safety for patients and operators alike is of utmost importance

to teams specializing in high-volume and complex aortic repairs. What measures does your team take in this regard?

Dr. Ullery: I commend many of our leaders in the field for raising awareness of this issue as we continue to push the envelope with increasingly complex endovascular interventions. Although construction of new facilities and retrofitting of older rooms have been marked by the addition of improved shielding and upgrading to state-of-the-art ceiling mounted imaging systems, we have also been proactive in trialing of newer avenues for radiation safety, such as zero gravity and Rampart, to further optimize the safety of our primary operating venues. Some of these options remain cost-prohibitive in the current financial climate, but I am optimistic that increased competition in this space will help drive these costs down in the future. Moreover, we regularly use CT fusion imaging for the majority of our complex aortic work to facilitate expeditious branch vessel catheterization and, as a result, minimize net fluoroscopy time and unnecessary digital subtraction angiography runs. As a default strategy, we also use the lowest frame rate possible for all our imaging series and liberally use digital magnification to obviate the need for increased radiation exposure with actual field view magnification. Lastly, our personal experience is similar to that of many other high-volume aortic centers insofar as we have embraced the many values of staging complex aortic repairs vis-à-vis reductions in both radiation exposure and spinal cord ischemia risk.

Dr. Azizzadeh: We adhere to the ALARA (as low as reasonably achievable) principle. We use all the standard protections feasible in every situation. We are also very encouraged by some of the new three-dimensional overlay imaging platforms that reduce radiation requirements. We are currently designing a new hybrid room that will take advantage of the latest technology.

Dr. Milner: We added Cydar imaging (Cydar Medical) last year. We have seen a reduction in our radiation exposure since adding this technology for our complex repairs.

Dr. Endicott: The most important measures involve taking time to reduce exposure while operating, such as limiting angiographic runs to those that are essential for performing the intervention, limiting time on the fluoroscopy pedal during the entire endovascular procedure for steps that are essential, and using collimation throughout the entire procedure. Particularly in complex aortic cases with intraabdominal imaging, it is important to limit angulation to times during the procedure that angulation is necessary. With steep angulation, placing the x-ray tube on the opposite side of the operator and placing a shield between the tube and the operator reduces the operator's dose. In our hybrid suites, we use shielding above and below the table placed between the operator and the x-ray tube.

Finally, wear your radiation badge and monitor your dose monthly. Elevated doses should lead to a discussion with your radiation safety officer about how to configure your suite to maximize your protection while being able to comfortably perform endovascular procedures. Periodic observation of endovascular procedures with your radiation safety officer can help maximize the team's "radiation hygiene" and provide valuable education to trainees who have a whole career working with radiation ahead of them.

Dr. Fatima: Radiation reduction can be accomplished through multiple different approaches. It is ideal for these procedures to be done in hybrid rooms with updated imaging and software to minimize radiation to the patient as well as the surgical team. Use of adjuncts such as fusion imaging, intravascular ultrasound, Fiber Optic RealShape (FORS; Philips), or Intra-Operative Positioning System (IOPS; Centerline Biomedical) can help significantly reduce radiation directly as well as by reducing total procedure time. Good radiation practice by individuals, such as proper attire, eye wear, use of glass shields, lead skirts, and judicious and thoughtful use of collimation and digital zoom, should be employed by everyone involved with complex aortic practice. ■

Disclosures
Dr. Azizzadeh: None.
Dr. Endicott: None.
Dr. Fatima: None.
Dr. Milner: Consultant to Cydar, Endospan, Medtronic, Silk Road, and WL Gore; equity interest in CyndRx.
Dr. Ullery: None.