

Pathway to cardiothoracic surgery: A primer for aspiring students



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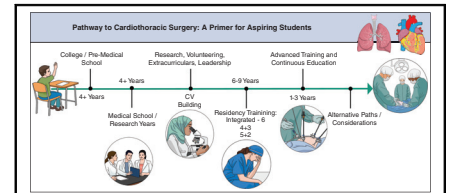
ABSTRACT

Objective: The pathway to cardiothoracic surgery is often obscure for premedical students and aspiring applicants and requires navigating various known and unknown obstacles. Recognizing the challenges encountered on the path to a career in cardiothoracic surgery in the United States, we present this guide for students interested in the field to maximize success in their premedical, preclinical, and pre-residency years.

Methods: This is a joint collaboration between the Thoracic Surgery Residents Association and the Thoracic Surgery Medical Student Association. Drawing from firsthand experiences and insights gathered from numerous student applicants and current surgical residents, a comprehensive guide was constructed for students from the point of undergraduate school to advanced training options, including super-fellowship training.

Results: Several intricacies to cardiothoracic surgery career planning were discussed, including differences between traditional and integrated/fast-track pathways, college and medical school selection, networking, performing during clinical rotations, extracurricular and research activities, building mentorship relationships, and pursuing alternate career and advanced training opportunities.

Conclusions: For premedical students and aspiring applicants, the road to cardiothoracic surgery requires meticulous planning, grit, and thoughtful dedication. This document consolidates firsthand insights and advice from numerous aspiring and matched applicants to serve as a comprehensive guide for students seeking a career in cardiovascular and thoracic surgery. (JTCVS Open 2024;20:112-22)



Schematic of pathway from premedical school to cardiothoracic surgery practice.

CENTRAL MESSAGE

The Thoracic Surgery Residents Association and T SMA have partnered to create a comprehensive primer detailing advice for undergraduate and medical students planning to apply for cardiothoracic surgical training.

PERSPECTIVE

For premedical students and aspiring applicants, the road to cardiothoracic surgery requires meticulous planning, grit, and thoughtful dedication. Recognizing the challenges encountered on the path to a career in cardiothoracic surgery in the United States, we present this guide for students interested in the field to maximize success in their premedical, preclinical, and pre-residency years.

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Abbreviations and Acronyms	
AATS	= American Association for Thoracic Surgery
AOA	= Alpha Omega Alpha
CV	= curriculum vitae
STS	= Society of Thoracic Surgeons
TSITE	= Thoracic Surgery Directors Association In-Training Exam
TSMA	= Thoracic Surgery Medical Student Association

Cardiothoracic surgery specializes in the surgical management of diseases of the thoracic cavity, including the heart and great vessels, airway and lungs, thymus, and esophagus. It is broadly divided into 3 subspecialties, including adult

cardiac surgery, general thoracic surgery, and congenital cardiac surgery (Table 1). The field was revolutionized in the early to mid-20th century with the advent of artificial ventilation, cardioplegic agents, and cardiopulmonary bypass technologies, which allowed for the arrest of heart and lung function and the creation of a motionless operative field for surgery. Today, several advances continue to shape clinical practice, including the adaptation of endovascular and hybrid technologies, minimally invasive and robotic techniques, and xenotransplantation. Cardiothoracic surgery requires technical skill and the ability to manage a spectrum of acute and chronic diseases in patients of different levels of complexity. More important, the field demands empathy and care for patients at their most vulnerable times when undergoing potentially life-threatening surgery.

For premedical students aspiring to be cardiothoracic surgeons, planning the journey can be overwhelming

TABLE 1. Cardiothoracic surgical subspecialties and common operations

Specialty	Populations served	Treated pathologies	Associated operations	Associated specialties/ healthcare providers
Adult Cardiac Surgery	-Adults	<ul style="list-style-type: none"> - Coronary artery disease - Aortic valve disease - Mitral valve disease - Tricuspid valve disease - Aortic aneurysms/dissections - Heart Failure 	<ul style="list-style-type: none"> - CABG - SAVR, TAVR, TAVR explants - Mitral valve repair/ replacement, MitraClip - Tricuspid valve repair/ replacement, TriClip - Open/endovascular aortic repair - ECMO/LVAD placement/Heart Transplant 	<ul style="list-style-type: none"> - Cardiologists - Interventional cardiologists - Intensivists - Vascular surgeons - Anesthesiologists - Radiologists - Perfusionists - Electrophysiologists
General Thoracic Surgery	- Adults	<ul style="list-style-type: none"> - Lung malignancy - Esophageal malignancy - Refractory gastrointestinal reflux disease - Hiatal, diaphragmatic hernias - Interstitial lung disease, chronic obstructive pulmonary disease, bronchiectasis, and pulmonary arterial hypertension - Thoracic outlet syndrome - Thymic epithelial tumors 	<ul style="list-style-type: none"> - Lung resection (lobectomy, wedge resection, segmentectomy) - Esophagectomy - Nissen fundoplication - Surgical hernia repair - Lung transplantation - First rib resection - Thymectomy 	<ul style="list-style-type: none"> - Pulmonologists - Interventional pulmonologists - Gastroenterologists - Intensivists - Medical oncologists - Anesthesiologists - Radiologists
Congenital Cardiothoracic Surgery	<ul style="list-style-type: none"> - Neonates - Children - Adults 	<ul style="list-style-type: none"> - Coarctation of the aorta - Tetralogy of Fallot - Patent ductus arteriosus closure - Atrioventricular septal defects - Transposition of great vessels - Hypoplastic left heart syndrome - Truncus arteriosus 	<ul style="list-style-type: none"> - Coarctation of the aorta repair (extended end-to-end anastomosis) - Complete tetralogy of Fallot repair - PAD ligation - Septal defect repair - Arterial switch for transposition of the great arteries, - Rastelli operation - Norwood-Glenn-Fontan series - Truncus arteriosus repair 	<ul style="list-style-type: none"> - Pediatric cardiologists - Intensivists - Perfusionists - Anesthesiologists - Radiologists

CABG, Coronary artery bypass grafting; SAVR, surgical aortic valve replacement; TAVR, transcatheter aortic valve replacement; ECMO, extracorporeal membrane oxygenation; LVAD, left ventricular assist device; PAD, pulmonary artery disease.

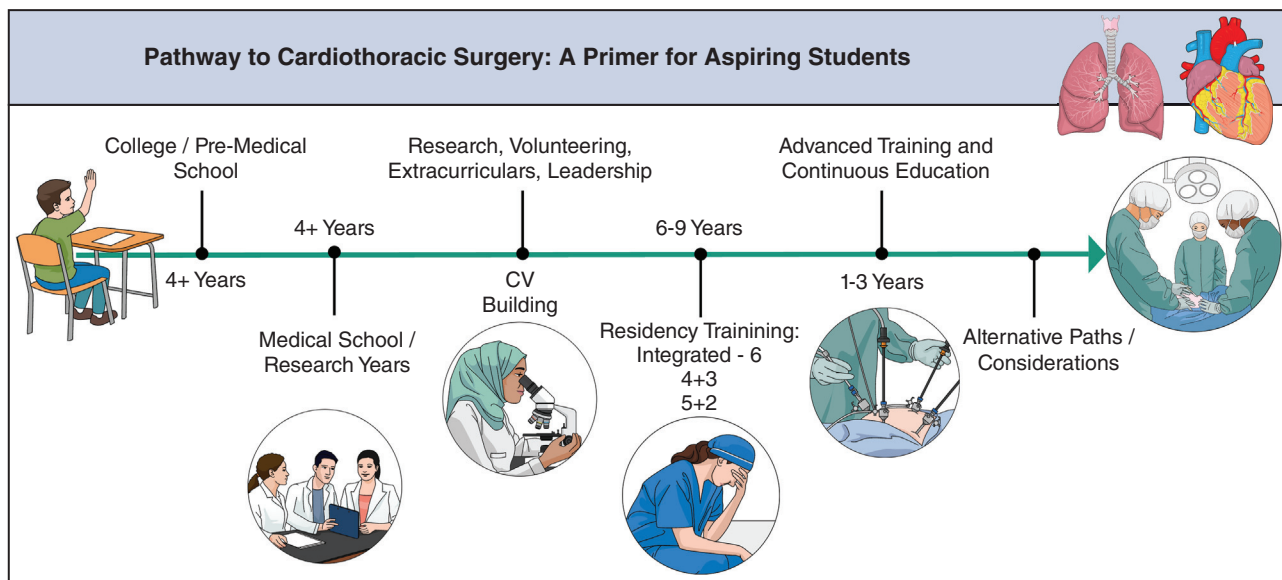


FIGURE 1. Schematic of pathway from premedical school to cardiothoracic surgery practice. CV, Curriculum vitae.

(Figure 1). It requires excelling in college and medical school, careful planning, detailed preparations, setting priorities, and dedication. There is no shortcut to becoming a cardiothoracic surgeon, considered one of the most challenging and time-intensive specialties to pursue after medical school training. Additionally, several studies have projected severe shortages in trained cardiothoracic surgeons in the future.¹ In light of these points, many recent publications have highlighted the importance of early career mentorship and education to increase the recruitment of qualified and driven applicants to the field.² Recognizing the challenges encountered by students on the path to a career in cardiothoracic surgery in the United States and the looming shortage of surgeons, we present this guide for students to promote interest in the field and maximize success during premedical, preclinical, and preridency years.

TRADITIONAL VERSUS INTEGRATED PATHWAYS

Currently, several training pathways exist for certification in the United States. These include the traditional 2- or 3-year cardiothoracic surgery fellowship following a 5-year general surgery residency, the “4 + 3” track consisting of 4 general surgery years plus 3 years of cardiothoracic surgery fellowship at the same institution, and the integrated 6-year (“I-6”) programs in which residents are exposed to cardiothoracic surgery from the beginning of their training after medical school.³ After residency, many desire further subspecialization and pursue advanced “super fellowships.” Others may decide between building a purely “clinical” practice, emphasizing a high surgical case volume, or a mix of academic and clinical practice, where they may operate less to dedicate time to academic research and training medical students and residents.

Traditional Pathway

The traditional track for becoming a cardiothoracic surgeon comprises 5 clinical years of general surgery residency followed by 2 or 3 years of cardiothoracic surgery fellowship. During general surgery training, residents sit for the annual American Board of Surgery In-Training Examination, typically administered in January or February. Additionally, cardiothoracic trainees will be expected to take the Thoracic Surgery Directors Association In-Training Exam (TSITE), which is offered in the spring of each year to evaluate general knowledge of cardiac and thoracic surgery topics in preparation for the written and oral thoracic surgery board exams. The advantages of this pathway include career flexibility, leadership experience, and a gradual learning curve. In particular, this pathway gives trainees exposure to various fields, which can be helpful if planning to pursue future subspecialty training. Proponents of the traditional pathway argue that the general surgery residency experience is valuable for building autonomy, team leadership, and decision-making skills while offering a more gradual learning curve. Trainees are first exposed to noncardiac operations, allowing more time to hone skills in tissue handling, ergonomics, suturing, and building operating room confidence. Additionally, trainees completing the traditional pathway can obtain board certification in both general and thoracic surgery.

Another possibility for applicants considering the traditional pathway could be to pursue vascular surgery residency training (in place of general surgery) before their cardiothoracic fellowship training. If done in this order, applicants would be required to sit in on annual Vascular Surgery In-Training Examinations during the first half of their training and would be double board-certified in both vascular and

cardiothoracic surgery. With the growing landscape of minimally invasive and transcatheter interventions, doing the traditional pathway in this manner may be appealing to applicants looking to develop “wire skills” early.

The disadvantages of the traditional pathway include additional time, potentially several years longer than other pathways, limited exposure to cardiac and thoracic surgery before fellowship, and limited opportunities to develop skills in interventional cardiology/pulmonology and cardiothoracic critical care.

Notably, there are a growing number of general surgery training programs, particularly those from academic institutions, that require an additional 1 to 2 years of research time in their curricula. Although this increases the length of training in the pathway, it does provide applicants with protected academic time that can be used to strengthen their application for cardiothoracic fellowship. Recent data have shown a drop in match rates to traditional cardiothoracic fellowships since 2012, with several programs prioritizing applicants with high scholarship during their general surgical training.⁴ In addition to conducting research, trainees in amenable programs may consider using their protected academic time to obtain certification in additional disciplines, such as critical care medicine.

Integrated Pathway

The integrated track (I-6) consists of 6 years of dedicated cardiothoracic surgery training, often with an additional 1 or 2 years of research. The first 2 or 3 years include at least 12 months of general surgery training covering related specialties such as vascular surgery, cardiology, cardiac electrophysiology, anesthesia, and critical care medicine, with the remaining time spent on cardiac or thoracic surgical services. Research time is typically between the postgraduate year (PGY)* 2 to 3 or PGY* 3 to 4 clinical years. Similar to traditional cardiothoracic surgery fellows, I-6 residents are required to sit for the TSITE exams every Spring. The advantages of I-6 training include early exposure and involvement in cardiothoracic surgical cases and early, focused study of cardiothoracic disease. However, the track is associated with a steeper learning curve for the inexperienced medical school graduate and is often considered a terminal pathway with limited flexibility in career choice. Applicants to the I-6 pathway may perceive it as a “shorter” training duration compared with the traditional training paradigm. It is important to note that many programs require additional research years and that many graduates choose to pursue additional super-fellowship training after residency, adding an additional 2 to 3 years. Therefore, applicants should be mindful of this when applying to realistically gauge their

timeline to independent practice. Most I-6 programs emphasize interest in cardiac and congenital surgery with few dedicated thoracic tracks. Finally, this is a very selective track. For the 2022 National Resident Matching Program Match, only 47 spots at 33 programs were available.⁵ For these reasons, it is important to ensure total commitment to a career as a cardiothoracic surgeon and honest assessment of competitiveness when considering the I-6 pathway.

Fast-Track (4 + 3) Pathway

For trainees looking for a clinical “middle-ground” between the traditional and integrated cardiothoracic pathways, the fast-track 4 + 3 training pathway is an excellent consideration. In this training paradigm, medical students apply to a general surgery residency program and complete 4 years of general surgery training before matriculating into a 3-year cardiothoracic fellowship. Similar to traditional pathway trainees, surgeons participating in the fast-track pathway are responsible for taking American Board of Surgery In-Training Examination and TSITE annually during their training. It is worth noting that acceptance into fellowship is not guaranteed, and an applicant will generally need to apply after completing their second year of the general surgery residency.⁶ However, the application process is often much less formal than the traditional pathway and will involve a review of an applicant’s performance in the program and discussion between the institution’s general and cardiothoracic surgery program leadership. In addition to general surgery training exposure, the fast-track pathway benefits include longitudinal training at the same institution and dual board certification in general and thoracic surgery. Currently, only 19 academic institutions offer the 4/3 training paradigm.⁷

For more information regarding the pathway(s) to cardiothoracic surgery, the Thoracic Surgery Residents Association, CTSNet,⁸ and Thoracic Surgery Medical Student Association (TSMA) provide materials, mentorship, and networking opportunities to young trainees and students of different years.

PREMEDICAL SCHOOL PREPARATION

We emphasize that students engage in a major that most interests them and strive for a competitive grade point average while completing medical school prerequisites. The notion that Science, Technology, Engineering, and Math majors are favored in medical school selection committees has limited supporting evidence.⁹ Applicants must understand and communicate how their strengths, interests, experiences, passions, and diversity will benefit the field of medicine, regardless of major. Applicants should be prepared to articulate how the lessons learned and habits developed during their undergraduate education have prepared them for a career as a physician. Additionally, US applicants will likely sit for the Medical College Admissions

*PGY is a nomenclature used to refer to how many years a resident has been in training since graduating medical school. For example, a PGY-1 is a first-year resident, or intern, and a PGY-3 and above are considered “chief residents.”

Test for medical school admissions. We recommend students be mindful of the various components of the Medical College Admissions Test (chemistry, physics, biology, biochemistry, psychology, and reading comprehension) to ensure their success on the exam and competitiveness when applying to medical schools. Several online resources are available to help students prepare for the exam. We recommend students use high-yield Khan Academy¹⁰ review videos to brush up on subjects they are weak in, along with Kaplan¹¹ and UWorld¹² practice examination question banks. When taking practice tests, try to do so under “test-like” conditions, prioritizing timed, uninterrupted sessions in a quiet area to stimulate test-like conditions. Additionally, many find repetition flashcard systems, such as Anki or Quizlet, to be very useful. An efficient practice is to create flashcards for each incorrect practice question.

Although many factors contribute to a successful residency application, a significant predictor of matching into an I-6 program was attending a top-40 National Institutes of Health–funded research institution for medical school.¹³ Therefore, a competitive medical school application is paramount, and attending a top-ranked medical school may provide additional research and mentorship opportunities, both of which are invaluable to a successful residency application. Of special note, applicants who are confident about applying to cardiothoracic surgery training should seek to attend medical schools with “home” integrated or traditional fellowship programs, because this will afford several advantages, including improved access to potential mentors, research projects, and observer/rotation opportunities.

When applying to both medical school and subsequent general surgery/cardiothoracic surgery residency, showcasing a diverse and comprehensive skill set, leadership abilities, and most important, a passion that aligns well with that of a particular program and the field is paramount. As a premedical student, engagement in research projects is often more accessible, can promote the development of a knowledge base in the field, and facilitates networking. We advise students to carefully research laboratories and Principal Investigators before beginning research activities. Identifying a “student-friendly” and productive laboratory can be as simple as quickly searching up the Research Gate and X accounts of potential Principal Investigators.¹⁴ Ideally, students can identify research teams that provide opportunities to gain the tools required to lead a project to completion. In particular, the ability to transform an oral or poster presentation into a peer-reviewed manuscript publication is a testament to one’s ability to think and produce as a future physician-scientist (Table 2). Early in their training, students should focus on developing high-yield research skills such as performing literature searches, using graphical software (eg, GraphPad Prism), using statistical software (eg, R, SPSS, Stata, SAS), and academic writing, which are widely applicable. Students can enroll in open

access/free courses on different online platforms such as Coursera,¹⁵ Edx,¹⁶ and YouTube.¹⁷

Apart from research, premedical students can demonstrate an interest in the field by shadowing field members and getting involved with groups focusing on cardiothoracic surgery, such as the American Association for Thoracic Surgery (AATS), Society of Thoracic Surgeons (STS), Eastern Cardiothoracic Surgical Society, Southern Thoracic Surgical Association, Western Thoracic Surgical Association, and Women in Thoracic Surgery. Leveraging research, shadowing, and volunteer experiences to develop mentorship relationships often yield impressive and unique letters of recommendation. Importantly, letters of recommendation from longitudinal mentors are invaluable. Notably, there are several traveling scholarships that students may apply to, such as the STS Looking To The Future Program¹⁸ and AATS Member for a Day program. In addition to being prestigious awards, these scholarships help provide a student interested in the field with financial assistance to attend a national meeting, network, and connect with a mentor in the field. Students may consider meaningful volunteerism to highlight selflessness and dedication to patient advocacy. Several nonprofit organizations may be considered, including but not limited to Doctors Without Borders, Aortic Hope, Think Aorta US, and Chain of Hope.^{19,20} Recently, the STS has initiated an annual Advocacy Conference, where members gather in the capital to advocate for crucial cardiothoracic healthcare policy reforms.²¹

MEDICAL SCHOOL

Academics

Academic excellence is a necessity for students interested in cardiothoracic surgery. The best study method will be determined by trial and error, but organization and time management often underlie the most successful approaches. We recommend using institutional academic offices, peer support groups, and specialized tutors early to establish beneficial practices rather than retroactively in response to poor performance. Likewise, using spaced-repetition study tools, such as Anki, will be beneficial for the long-term retention of information necessary to perform well on exams. Although many medical schools are transitioning to a pass/fail curriculum, most are still affiliated with the Alpha Omega Alpha (AOA) Honor Society and Gold Humanism Honor Society. AOA and Gold Humanism Honor Society status are solid additions to any residency application but are not required.

Research

Early involvement in research activity, mentorship building, and networking with like-minded peers while maintaining academic excellence is highly beneficial for medical students interested in cardiothoracic surgery residency.²²⁻²⁴ With the recent shift of the US Medical Licensing Exam

TABLE 2. Different forms of research publications that can be formatted to curriculum vitae

Publication type	Description	Pros	Cons
Abstract	<ul style="list-style-type: none"> - Brief (250-500 word) summary of preliminary research findings - Will be published on journal websites or in abstract handbook - Usually no formal presentation associated with it (text-only medium) - Usually limited to 1-2 visual figures/tables 	<ul style="list-style-type: none"> - Gives you a chance to share early findings with the field and gain advice - Relatively less-time consuming than other research mediums - Can be published without the need to travel anywhere - Tend to be accepted or rejected in 1-2 rounds of review 	<ul style="list-style-type: none"> - Less prestigious than presentations or peer-reviewed manuscripts - Limited text/figure space
Poster Presentation	<ul style="list-style-type: none"> - Visual representation of preliminary or finalized research findings - Will be displayed in conference halls with other posters for attendees to walk and view - May or may not have a spoken component - Usually limited to a preset slide template with size/text constraints 	<ul style="list-style-type: none"> - Allows you the opportunity to share your work live at regional and national meetings - Some conferences have associated journals that will be interested in full manuscript after the conference is concluded 	<ul style="list-style-type: none"> - Less prestigious than oral presentations or peer-reviewed manuscripts - Public speaking may be nerve-wracking for some people (for posters with spoken component) - Travel/conference registration expenses
Oral Presentation	<ul style="list-style-type: none"> - Visual/oral representation of preliminary or finalized research findings - Tend to be the “best” or most provocative abstracts submitted to a conference - Will be presented in dedicated conference rooms with a live audience and usually panelist discussion/questions 	<ul style="list-style-type: none"> - Gives your research a large audience allowing constructive feedback - Some conferences have associated journals that will be interested in full manuscript after the conference is concluded 	<ul style="list-style-type: none"> - Public speaking may be nerve-wracking for some people - Travel/conference registration expenses
Peer-reviewed Manuscript	<ul style="list-style-type: none"> - Written representation of finalized research findings that will undergo editorial board review by journal house staff and/or invited external editors - Larger text and figure limitations - Will be published on journal websites/in-print and when applicable indexed in medical libraries 	<ul style="list-style-type: none"> - Generally considered the “pinnacle” of research-sharing mediums as many expect an abstract or poster to yield a final manuscript result in the end - Most word and figure space to comprehensively share your data/work 	<ul style="list-style-type: none"> - Submission/author fees if submitting to open access journals - Most time-consuming - Very long peer-review process compared to other forms of research (several weeks to months over several rounds of review)

Step 1 to pass/fail scoring, research productivity has become an increasingly important differentiator in residency applications. The breadth of cardiothoracic surgery research and the current state of research in the field can be gleaned from regularly reading key journals in the field.

This can be facilitated by subscribing to email alerts from journals such as *The Annals of Thoracic Surgery*, *The Journal of Thoracic and Cardiovascular Surgery*, and *The Journal of Heart and Lung Transplantation*. We recommend attending institutional research meetings to

become acquainted with faculty, residents, and projects that may be of interest. If an institution lacks a cardiothoracic surgery department, applicants should reach out to other surgical departments at their school or consider connecting with cardiothoracic surgery departments at other institutions. Publishing high-quality, meaningful research is nearly impossible without mentors who are invested in your career goals. Consequently, identifying and developing a relationship with a research mentor are critical. Additionally, finding like-minded students with varying research skills to collaborate with may be a productive strategy.

Given that many cardiothoracic surgery-oriented applicants apply solely to general surgery programs or dual apply to I-6 programs, conducting research related to both cardiothoracic and general surgery may be beneficial. This will be particularly important for dual applicants, because research portfolios that are too “cardiothoracic” focused may inevitably be a concern for general surgery programs that want to see an applicant’s commitment to noncardiothoracic surgical fields as well. Ensuring one can adequately contribute to and lead research projects will also be a crucial skill to maintain during residency, as contributing to their home department’s academic output is often an “unwritten” rule for trainees.²⁵ Furthermore, for those training in a traditional community general surgery program, remaining involved in high-quality academic research will be very important when applying to a competitive cardiothoracic surgery fellowship down the road. Trainees may consider working with their program directors to organize dedicated in-house or away cardiothoracic surgery rotations or use protected research time to work in a cardiothoracic clinical or basic science research laboratory.

Networking

Networking allows medical students to connect with peers and faculty nationwide and is an important aspect of the residency application. We recommend students create a professional Twitter/X account, which can be used to share early career accomplishments and give them the opportunity to connect with other aspiring applicants and members of the field. Students can begin by following the Thoracic Surgery Medical Student Association (@ThoracicStudent) X page, which provides opportunities to connect with surgeons and peers outside of their institution. Cardiothoracic surgical society meetings are an excellent opportunity for students to introduce themselves to faculty surgeons and program directors, because this is an important factor for programs to extend applicants interview invites.²² Notably, the AATS, STS, Eastern Cardiothoracic Surgical Society, and Women in Thoracic Surgery offer travel scholarships for students to attend academic meetings²⁶ and connect with potential mentors and colleagues.²⁷ Last, surgery interest groups, grand rounds, residency education sessions, and the operating room are often

underappreciated settings where students can network with cardiothoracic surgery faculty.²⁸

Extracurriculars

Extracurricular activities demonstrate a balanced personality. Commitments, however, should be informed purely by interest and passion. Several options exist, including involvement with the TSMA and medical initiatives serving underrepresented groups, such as the Student National Medical Association, Latino Medical Student Association, and Medical Student Pride Alliance. Students can volunteer and later apply for leadership positions within these groups, which speaks to their passion and leadership ability. Other historically popular extracurriculars include musical talents and athletics involvement.

Many students seek leadership positions in interest groups, which can be excellent topics of conversation during residency interviews. Extracurricular activities allow students to maintain personal identity and growth during training and demonstrate an ability to optimize work-life balance, a valuable indicator of maturity and longevity. We reiterate, however, that a laundry list of activities with minimal involvement is less valuable than a small number of extracurricular activities to which an applicant has made substantial contributions as a leader.

Clinical Year Rotations and Mentorship

The third year of medical school is an exciting and demanding transition, requiring students to consolidate their interests and break ground on residency applications. During core specialty rotations, learning shifts from didactic lectures to practical experience on the wards, necessitating efficiency, organization, and proactivity. The evaluation process transforms into subjective, performance-based assessments, focusing on clinical competencies and professionalism in core fields, such as medicine, pediatrics, obstetrics/gynecology, and general surgery. When available, students should use elective rotation blocks to rotate through cardiac, thoracic, general, and vascular surgery services to gain exposure. Although these rotations are often more intensive than some of the nonsurgical core rotations, several resources are available to help students prepare, including the Thoracic Surgery Residents Association/TSMA Primer Series,²⁹ CTSNet (<https://www.ctsnet.org>), and The Multimedia Manual of Cardio-Thoracic Surgery (<https://mmcts.org>). Before starting these rotations, students would benefit greatly from taking time to develop technical skills, such as common suturing patterns and 1-hand and 2-hand knot tying. Additionally, students should use these rotations to identify operative strengths and weaknesses and evaluate if surgery is right for them. Specific considerations a student should make include things such as the intensive schedule, unpredictable returns to the hospital for emergencies, and the physical demands of the job, such as skipping

meals as needed for cases and standing during cases that may take several hours.

Identifying general and cardiothoracic surgical mentors should be a priority during clerkship years, if not already completed. We recommend scheduling in-person meetings with attending faculty before rotating on general and cardiothoracic surgical services to create an opportunity for clinical performance to be assessed with the intent of garnering letters of recommendations because most students will be dual-applying to both traditional and integrated training programs. This meeting should allow one to clearly articulate clinical interests, career goals, and desire to continue longitudinal involvement with the faculty member/division through scholarly projects. Preemptive meetings also allow mentors to reach out to colleagues and may optimize the clinical and educational opportunities during the upcoming rotation. In addition to attendings, mentorship relationships with residents can yield practical advice for success on the wards and in the early years of training. This is particularly helpful when deciding on a program because residents can provide firsthand insight about their training programs and advice on preparing an application to match.

Before starting the fourth year, it is recommended to meet with these mentors to review curriculum vitae (CV) items, evaluations, board scores, and so forth to receive honest feedback on important decisions such as applying to sub-internships or deciding between the traditional or integrated pathway. The depth of your relationship will ultimately determine the authenticity of the letter of recommendation a mentor will write. The letter is a generally accepted responsibility of a good mentor; however, it is equally accepted that a mentee requests letters of recommendation well before application deadlines (months) and provides writers with an organized application and current CV. Many may value well-recognized or influential letter writers, but we reiterate that a personal, honest, and informed letter of recommendation is invaluable.

Application Cycle and the Match

Part I: Preparing and submitting applications. The fourth year of medical school requires students to balance clinical and educational duties with extracurricular and research obligations in anticipation of the upcoming Match cycle. This time can be fraught with uncertainty; we encourage applicants to trust their instincts and rely on support from mentors of varying levels.

Away rotations and sub-internships. For students who are certain that they want to pursue a career in cardiothoracic surgery, the selection of the intended residency pathway is paramount. This decision will inform fourth year sub-internship rotation. For the 4 + 3 and traditional applicants, time on general surgery services is recommended. Conversely, for a candidate applying to I-6 programs,

away rotations and repeat rotations on cardiothoracic surgery services are recommended in addition to general surgery home sub-internships to expose themselves to a wide breadth of surgical pathologies and management and to secure high-quality recommendation letters. Completion of away rotations allows students to see firsthand how different training programs are organized, which will be helpful when determining their “rank list” for residency.

Additionally, these rotations serve as a month-long “audition,” allowing students to showcase their passion for the field, teachability, and ability to function at the level of an “intern,” all of which can make them stand out during the application review process. For those students who do not come from home rotations, completing and excelling at away rotations will also provide a much-needed opportunity to secure strong clinical letters of recommendation. For further information on how to prepare for an away rotation, we highly recommend reading our previously published primer series.²⁹

Assessing your competitiveness. When beginning to prepare applications for residency, students should take time to self-reflect on their accomplishments and performances on general and cardiothoracic surgery rotations. Special consideration should be taken regarding their intraoperative performance, technical skills, ability to manage patients preoperatively and postoperatively, and overall comfort learning and being a contributing member of the service. Additionally, several studies have been published in the past detailing various components of a “successful” application,^{22,30} including scoring high (>250) on the US Medical Licensing Exam Step 2 examinations, having letters of recommendation from members of the specialty, AOA membership, and having a higher number (>7) of abstract and poster presentations.

Applying to residency. The application to residency signifies the culmination of undergraduate and medical school efforts. Maintaining an updated CV will facilitate completing the application via the Electronic Residency Application Service. It requires applicants to list extracurricular activities as “volunteer activities,” “research activities,” “work activities,” and “research publications.” Of note, publications may be categorized as published, submitted, oral presentation, or poster presentation (in order of importance). When dual applying, applicants should consider requesting separate letters of recommendation tailored for either general surgery or cardiothoracic surgery applications; this can be in the form of entirely separate letter writers or the same writer who writes 2 letters (these 2 letters need not be *very* different). General surgery program directors may favor letters from general surgeons who can speak to an applicant’s interest in pursuing the traditional pathway; likewise, I-6 program directors will be interested to hear from cardiothoracic surgeons regarding an applicant’s suitability for the integrated pathway. Letters from

thoracic surgeons are acceptable for general surgery applications because thoracic surgery continues to be a core rotation in general surgery programs. Some integrated programs and many general surgery programs also require a Chair of Surgery letter. We recommend meeting with letter writers in person and well before submission deadlines (2-3 months prior) to ensure thoughtful and personalized letters of recommendation. An honest discussion with letter writers regarding passions, career goals, strengths, and weaknesses often allows for a customized narrative that will stand out from more “standardized” letters.

Part II: Interviews and the match. *Interviews.* Before interviews, it is recommended to review one’s entire CV and Electronic Residency Application Service application. Interviewers read applications to generate questions/topics for discussion. Thus, it is imperative that any item within one’s application can be comfortably discussed in detail. Interview preparation is essential because it communicates an applicant’s interest in a particular program. We recommend being able to provide an “elevator pitch” about one’s desire to train at a particular location and why one may be a benefit to a given program. Key questions to ask programs may include those about the diversity of faculty and residents, location, quality of life, research and professional development opportunities, operative autonomy, work-life balance, call schedule, and resident and faculty camaraderie. Additionally, applicants who already know that they hope to pursue a more cardiac- or thoracic-focused practice in the future can use interviews to gauge institutional volume of cases in each and whether they offer dedicated “tracks” for applicants to spend additional time mastering complex cases in that subspecialty.

Interviewers often ask standardized and behavioral questions. Reflecting on important experiences in both clinical and nonclinical settings regarding leadership, teamwork, ethical scenarios, learning style, teaching style, and patient interactions provides helpful examples to illustrate personal qualities in response to these questions. For integrated programs, interview day performance has been shown to significantly impact candidate rank order.²⁴ We remind applicants to approach this period of life with confidence and to find joy in the process: Enthusiasm toward a residency program and a firm belief in one’s ability to succeed will ensure the best chance of success.

The interview landscape has changed greatly since the COVID-19 pandemic with several programs now using a hybrid or virtual interview format. Students looking to learn more about a program they did not get a chance to do a rotation in may consider setting up a “second look” after weighing their interest and the financial costs of travel. Further to this point, for institutions with a “mandatory” second look for applicants that they interview, students should carefully consider their genuine interest and chances of matching into that program before committing to travel.

The match. Match day is not always a day of absolute happiness. Many individuals have mixed emotions regardless of where they match on their list. This can range from excitement about starting the next chapter in their journey, anxiety about moving to a new location, disappointment in not matching at a top choice, and uncertainty regarding the future. It is important to assess expectations realistically and rely on one’s support system to process and respond to the range of possible Match outcomes. If unsuccessful in the Match, options to pursue a career in cardiothoracic surgery remain available, including a preliminary general surgery year, a shift to another specialty during the Supplemental Offer and Acceptance Program process, or deferred graduation to pursue an advanced degree or research time.³¹

ADVANCED TRAINING AND CONTINUING EDUCATION

Over the past few decades, work-hour regulations, rising patient acuity, increasing complexity of advancements in surgical technology, and the exponential growth of medical discovery have led to increasing demands for surgical excellence and expertise.^{32,33} Academic centers have taken the lead in meeting these demands by actively recruiting highly trained, specialized surgeons. This has led graduates of traditional cardiothoracic fellowships and I-6 residencies to seek additional training to increase their competitiveness in the job market. Because of the breadth that cardiothoracic surgery covers, it has been especially influenced by this trend leading to its subsequent branching toward “super-specialization.” In support of this shift, advanced surgical training has been associated with decreased patient morbidity and mortality rates.³⁴⁻³⁶ The key question that each graduate must answer is whether additional training is necessary to reach their professional goals.

As mentioned, many of these programs are not Accreditation Council for Graduate Medical Education accredited and therefore not standardized. In general, the length of training for almost all advanced fellowships is 1 year, but a few can last up to 2 or even 3 years. Although limited, some accredited fellowships exist.^{36,37} As such, there is often some overlap in the scope of training and slight variations in the naming of institution-specific fellowships.³⁸ In addition to the fellowships we listed, a few unique opportunities exist throughout the United States focused on particular areas of cardiothoracic surgery, such as the AATS Matthew Gerdisch Fellowship in Arrhythmia Surgery. Although trainees often choose only 1 advanced fellowship to embellish their skills repertoire, it is important to note that surgeons can decide to dual-specialize by completing 2 advanced fellowships if desired. An example of such a combination includes minimally invasive surgery and transplant surgery.³⁶ To further help guide one’s decision in eventually pursuing advanced

fellowships, medical students are encouraged to be astute in seeking opportunities during medical school that develop their unique interests in cardiothoracic surgery.

ALTERNATIVE PATHWAY AND CONSIDERATIONS

Some students pause their medical education by taking a year off to complete research (Table 3). This often occurs in the last 2 years of medical school (institution-dependent). A so-called research or gap year allows students to delve into a passion project, strengthen their residency application, or support a couple’s match. If considering a gap year, we suggest discussing the decision with school advisors and cardiothoracic surgery mentors, among others in your support system. With a traditional curriculum, taking a year off after the second year may better allow for project completion and manuscript publication before residency applications. Pursuing a dual degree is another increasingly popular option. A dual degree provides a structured opportunity for deep and applied learning within a given field, such as an MS, MPH, MBA, PhD, or JD.

CONCLUSIONS

The path to cardiothoracic surgery is a complex journey that demands unwavering passion, grit, and a lifelong commitment to learning. While many aspiring applicants may wait until they are in medical school to start exploring the field, it is never too early to begin nurturing your passion and building your application. But note, it is imperative to remember that this journey is a marathon, and paying meticulous attention to *each* step is crucial. However, rather than feeling overwhelmed by the challenges ahead on your path to becoming a cardiothoracic surgeon, we would challenge interested students to rather find beauty in each step along the way.

Enjoy the hours you have during college and medical school to gain a broad and holistic education. Use free time to develop practical technical and academic skills that will make you stand out in any residency program. Engage in high-quality research and meaningful extracurricular activities that matter to you. Most important, remember that you cannot and will not be able to care for

TABLE 3. Highlighted programs for a dedicated medical school “research year”

Programs/URLs	Details
TL1 Predoctoral Clinical Research Program (Washington University in St Louis): https://crtc.wustl.edu/programs/predoctoral/tl1predoc/	Deadline: Applications open August to February. Annual stipend, 1-y and 2-y programs
Sarnoff Cardiovascular Research Fellowship: https://www.sarnofffoundation.org/	Deadline: Early January Annual stipend, membership to AHA, lifelong support to attend Sarnoff meetings, stipend for up to 2 annual meetings for presentations of your fellowship work, relocation allowance, option for second-year funding
AHA Predoctoral Fellowship https://professional.heart.org/en/research-programs/application-information/predoctoral-fellowship	Deadline: September Annual stipend, health insurance, project support
NIH Medical Research Scholars Program: https://www.cc.nih.gov/training/mrsp	Deadline: Early January Annual stipend, residential housing, relocation allowance, funding for conferences/textbooks/scientific endeavors
NIH Oxford-Cambridge Scholars Program (OxCam): https://oxcam.gpp.nih.gov	Applications open in August PhD funding
Year-Off Training Program for Graduate of Medical Students in Clinical and Translational Science (Rockefeller University): https://www2.rockefeller.edu/ccts/training/medstudentprogram	
NIH Global Health Program for Fellows and Scholars: https://www.fic.nih.gov/Programs/Pages/scholars-fellows-global-health.aspx	Deadline: August
Fulbright-Fogarty Fellows in Public Health https://us.fulbrightonline.org/applicants/types-of-awards/fulbright-fogarty-fellowships-in-public-health	
Stanford Biodesign Fellowship: https://biodesign.stanford.edu/programs/fellowships/innovation-fellowships.html	- Deadline: August. Applications open in May. - \$5464 per mo, plus a 1-time \$1000 computer stipend. Stanford University health insurance coverage.

Many of these are not cardiovascular or thoracic-specific. AHA, American Heart Association; NIH, National Institutes of Health.

someone else if you are not taking care of yourself. So, above all else, be sure to prioritize your health and happiness and make time for the things and people you love. We hope you find this guide useful as you take the first steps toward the cardiothoracic operating room.

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