Pathway to Cardiothoracic Surgery: A Primer for Aspiring Students

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Central Picture. Schematic of pathway from pre-medical school to cardiothoracic surgery practice.
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Central Message

TSRA and TSMA have partnered to create a comprehensive primer detailing advice for undergraduate and medical students planning to apply for cardiothoracic surgical training.

Perspective

For pre-medical 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 pre-medical, pre-clinical, and pre-residency years.
Abstract

Objective: The pathway to cardiothoracic surgery is often obscure for pre-medical 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 pre-medical, pre-clinical, and pre-residency years.

Methods: This is a joint collaboration between the Thoracic Surgery Residents Association (TSRA) and the Thoracic Surgery Medical Student Association (TSMA). 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 pre-medical students and aspiring applicants, the road to cardiothoracic surgery requires meticulous planning, grit, and thoughtful dedication. This document consolidates first-handed 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.
Key Words: residency; education; students
I. INTRODUCTION

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 three 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 importantly, the field demands empathy and care for patients at their most vulnerable times when undergoing potentially life-threatening surgery.

For pre-medical students aspiring to be cardiothoracic surgeons, planning the journey can be overwhelming. 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
II. Traditional vs. Integrated Pathways

Currently, several training pathways exist for certification in the United States. These include the traditional two- or three-year cardiothoracic surgery fellowship following a five-year general surgery residency, the “4+3” track consisting of four general surgery years plus three years of cardiothoracic surgery fellowship at the same institution, and the integrated six-year (“I-6”) programs in which residents are exposed to cardiothoracic surgery from the beginning of their training after medical school. After residency, many desire further sub-specialization 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 five clinical years of general surgery residency followed by two or three years of cardiothoracic surgery fellowship. During general surgery training, residents sit for the annual American Board of Surgery In-Training Examination (ABSITE), typically administered in January or February. Additionally, cardiothoracic trainees will be expected to take the Thoracic Surgery Directors Association (TSDA) In-Training Exam, or 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 non-cardiac 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 (VSITE) 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 prior to 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 1-2 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 has 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. 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 six years of dedicated cardiothoracic surgery training, often with an additional one or two years of research. The first two or three 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 PGY* 2-3 or PGY* 3-4 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 to the traditional training paradigm, it is important to note that many programs require additional research years and many graduates choose to pursue additional super-fellowship training after residency, adding an additional 2-3 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 (NRMP) 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.

* PGY: Post-Graduate Year, 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.”
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 four 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 ABSITE 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. 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 pathways 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.

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

III. PRE-MEDICAL 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 (STEM) majors are favored in medical school
selection committees has limited supporting evidence. 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, U.S. applicants will likely sit for the Medical College Admissions Test (MCAT) for medical school admissions. We recommend students be mindful of the various components of the MCAT (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 utilize high-yield Khan Academy\textsuperscript{10} review videos to brush up on subjects they are weak in, along with Kaplan\textsuperscript{11} and UWorld\textsuperscript{12} 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 NIH-funded research institution for medical school.\textsuperscript{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,
as 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 importantly, a passion that aligns well with that of a particular program and the field is paramount. As a pre-medical 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 (PIs) before beginning research activities. Identifying a “student-friendly” and productive lab can be as simple as quickly searching up the Research Gate and X accounts of potential PIs. 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 (e.g., GraphPad Prism), using statistical software (e.g., 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, Edx, and YouTube.

Apart from research, pre-medical 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), the Society of Thoracic Surgeons (STS), Eastern Cardiothoracic Surgical Society (ECTSS), Southern Thoracic Surgical Association (STSA), Western Thoracic Surgical Association (WTSA), and Women in Thoracic
Surgery (WTS). 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 Program\(^\text{18}\) 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 non-profit organizations may be considered, including but not limited to Doctors Without Borders, Aortic Hope, Think Aorta US, and Chain of Hope.\(^\text{19,20}\) Recently, STS has initiated an annual Advocacy Conference, where members gather in the capital to advocate for crucial CT healthcare policy reforms.\(^\text{21}\)
IV. 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 utilizing institutional academic offices, peer support groups, and specialized tutors early to establish beneficial practices rather than retroactively in response to poor performance. Similarly, utilizing 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 (GHHS). AOA and GHHS status is a solid addition to any residency application but is 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. With the recent shift of the U.S. Medical Licensing Exam (USMLE) 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 & 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 is 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, as research portfolios that are too “cardiothoracic”-focused may inevitably be a concern for general surgery programs who want to see an applicant’s commitment to non-cardiothoracic 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. 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 lab.
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, as this is an important factor for programs to extend applicants interview invites.\textsuperscript{22} Notably, the AATS, STS, ECTSS, and WTS offer travel scholarships for students to attend academic meetings\textsuperscript{26} and connect with potential mentors and colleagues.\textsuperscript{27} Lastly, surgery interest groups, grand rounds, residency education sessions, and the operating room are often underappreciated settings where students can network with cardiothoracic surgery faculty.\textsuperscript{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 Students 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. Extracurriculars 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 extracurriculars 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 utilize elective rotation blocks to rotate through cardiac, thoracic, general, and vascular surgery services to gain exposure. While these rotations are often more intensive than some of the non-surgical core rotations, several resources are available to help students prepare, including the TSRA/TSM Primer Series, 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 one-hand and two-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 as 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 as residents can provide first-hand insight about their training programs and advice on preparing an application to match.

Before starting 4th year, it is recommended to meet with these mentors to review CV items, evaluations, board scores, etc. 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 & 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 upon support from mentors of varying levels.

**Away Rotations & Sub-Internships**

For students who are certain that they wish to pursue a career in cardiothoracic surgery, the selection of the intended residency pathway is paramount. This decision will inform 4th 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/or 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 first-hand 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.\textsuperscript{29}

\section*{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 intra-operative performance, technical skills, ability to manage patients pre- and post-operatively, 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,\textsuperscript{22,30} including scoring high (\(>250\)) on the USMLE 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.

\section*{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 (ERAS). It requires applicants to list extracurricular activities as “volunteer activities,” “research activities,” “work activities,” and/or “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 two letters (these two 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 since 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 & The Match

Interviews

Before interviews, it is recommended to review one’s entire CV and ERAS 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 as 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 utilize 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. We remind applicants to approach this period of life with confidence and to find joy in the process: enthusiasm towards 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 utilizing 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 upon 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 (SOAP) process, or deferred graduation to pursue an advanced degree or research time.31
V. Advanced training & 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. 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. Due to the breadth that cardiothoracic surgery covers, it has been especially influenced by this trend leading to its subsequent branching towards “super-specialization.” In support of this shift, advanced surgical training has been associated with decreased patient morbidity and mortality rates. 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 ACGME accredited and therefore not standardized. In general, the length of training for almost all advanced fellowships is one year long, but a few can last up to two or even three years. Albeit limited, some accredited fellowships exist. As such, there is often some overlap in the scope of training and slight variations in the naming of institution-specific fellowships. 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. While trainees often only choose one advanced fellowship to embellish their skills repertoire, it is important to note that surgeons can decide to dual-specialize by completing two advanced fellowships if desired. An example of such a combination includes minimally invasive surgery and transplant surgery. 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.
VI. Alternative Pathway & Considerations

Some students pause their medical education by taking a year off to complete research (Table-3). This often occurs in the last two 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 2nd 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.
VII. Conclusion

The path to CT surgery is a complex journey that demands unwavering passion, grit, and a lifelong commitment to learning. While many aspiring applicants may wait until they're 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 CT 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 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 importantly, remember that you cannot and will not be able to care for 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.
References


Figure 1: Schematic of pathway from pre-medical school to cardiothoracic surgery practice
**Table 1.** Cardiothoracic surgical subspecialties and common operations

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Populations Served</th>
<th>Treated Pathologies</th>
<th>Associated Operations</th>
<th>Associated Specialties / Healthcare Providers</th>
</tr>
</thead>
</table>
| Adult Cardiac Surgery      | - Adults           | - Coronary artery disease  
- Aortic Valve Disease  
- Mitral Valve Disease  
- Tricuspid Valve disease  
- Aortic aneurysms / dissections  
- Heart Failure | - CABG  
- SAVR, TAVR, TAVR explants  
- Mitral valve repair/replacement, MitraClip  
- Tricuspid valve repair/replacement, TriClip  
- Open / endovascular aortic repair  
- ECMO/LVAD placement / Heart Transplant | - Cardiologists  
- Interventional cardiologists  
- Intensivists  
- Vascular surgeons  
- Anesthesiologists  
- Radiologists  
- Perfusionists  
- Electrophysiologists |
| General Thoracic Surgery   | - Adults           | - Lung malignancy  
- Esophageal malignancy  
- Refractory gastrointestinal reflux disease  
- Hiatal, diaphragmatic Hernias  
- Interstitial lung disease, chronic obstructive pulmonary | - Lung resection (lobectomy, wedge resection, segmentectomy)  
- Esophagectomy  
- Nissen fundoplication  
- Surgical hernia repair  
- Lung transplantation | - Pulmonologists  
- Interventional pulmonologists  
- Gastroenterologists  
- Intensivists  
- Medical oncologists  
- Anesthesiologists  
- Radiologists |
<table>
<thead>
<tr>
<th>Congenital Cardiothoracic Surgery</th>
<th>- Neonates</th>
<th>- Coarctation of the aorta</th>
<th>- Coarctation of the aorta repair (Extended End-to-End Anastomosis)</th>
<th>- Pediatric cardiologists</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Children</td>
<td>- Tetralogy of Fallot (TOF)</td>
<td>- Complete ToF repair</td>
<td>- Intensivists</td>
</tr>
<tr>
<td></td>
<td>- Adults</td>
<td>- Patent ductus arteriosus (PDA) closure</td>
<td>- PAD ligation</td>
<td>- Perfusionists</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Atrioventricular septal defects (AVSD)</td>
<td>- Septal defect repair</td>
<td>- Anesthesiologists</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Transposition of Great Vessels</td>
<td>- Arterial switch for transposition of the great arteries, Rastelli Operation</td>
<td>- Radiologists</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Hypoplastic Left Heart Syndrome</td>
<td>- Norwood-Glenn-Fontan series</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Truncus arteriosus</td>
<td>- Truncus arteriosus repair</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Different forms of research publications that can be formatted to CV.

<table>
<thead>
<tr>
<th>Publication Type</th>
<th>Description</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| **Abstract**     | - 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  
                   - 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 | - Less prestigious than presentations or peer-reviewed manuscripts  
                   - Limited text/figure space | |
| **Poster Presentation** | - 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 pre-set slide template with size/text constraints  
                   - 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 | - 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** | - 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  
                   - 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 | - Public speaking may be nerve-wracking for some people  
                   - Travel/conference registration expenses | |
| **Peer-reviewed Manuscript** | - 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 | - 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 | - 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) |
Table 3. Highlighted programs for a dedicated medical school “research-year.”

<table>
<thead>
<tr>
<th>Programs/URLs</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sarnoff Cardiovascular Research Fellowship: <a href="https://www.sarnofffoundation.org/">https://www.sarnofffoundation.org/</a></td>
<td>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 2nd year funding</td>
</tr>
<tr>
<td>AHA Predoctoral Fellowship <a href="https://professional.heart.org/en/research-programs/application-information/predoctoral-fellowship">https://professional.heart.org/en/research-programs/application-information/predoctoral-fellowship</a></td>
<td>Deadline: September Annual stipend, health insurance, project support</td>
</tr>
<tr>
<td>NIH Medical Research Scholars Program: <a href="https://www.cc.nih.gov/training/mrsp">https://www.cc.nih.gov/training/mrsp</a></td>
<td>Deadline: Early January Annual stipend, residential housing, relocation allowance, funding for conferences/textbooks/scientific endeavors</td>
</tr>
<tr>
<td>NIH Oxford-Cambridge Scholars Program (OxCam): <a href="https://oxcam.gpp.nih.gov">https://oxcam.gpp.nih.gov</a></td>
<td>Applications open in August PhD funding</td>
</tr>
<tr>
<td>Year-Off Training Program for Graduate of Medical Students in Clinical and Translational Science (Rockefeller University): <a href="https://www2.rockefeller.edu/ccts/training/medstudentprogram">https://www2.rockefeller.edu/ccts/training/medstudentprogram</a></td>
<td></td>
</tr>
<tr>
<td>NIH Global Health Program for Fellows and Scholars: <a href="https://www.fic.nih.gov/Programs/Pages/scholars-fellows-global-health.aspx">https://www.fic.nih.gov/Programs/Pages/scholars-fellows-global-health.aspx</a></td>
<td>Deadline: August</td>
</tr>
</tbody>
</table>

*Many of these are not cardiovascular or thoracic-specific*
Pathway to Cardiothoracic Surgery: A Primer for Aspiring Students

- College / Pre-Medical School
- 4+ Years
- Medical School / Research Years
- 4+ Years
- Research, Volunteering, Extracurriculars, Leadership
- 6-9 Years
- CV Building
- Advanced Training and Continuous Education
- 1-3 years
- Residency Training: Integrated - 6
- 4+3
- 5+2
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