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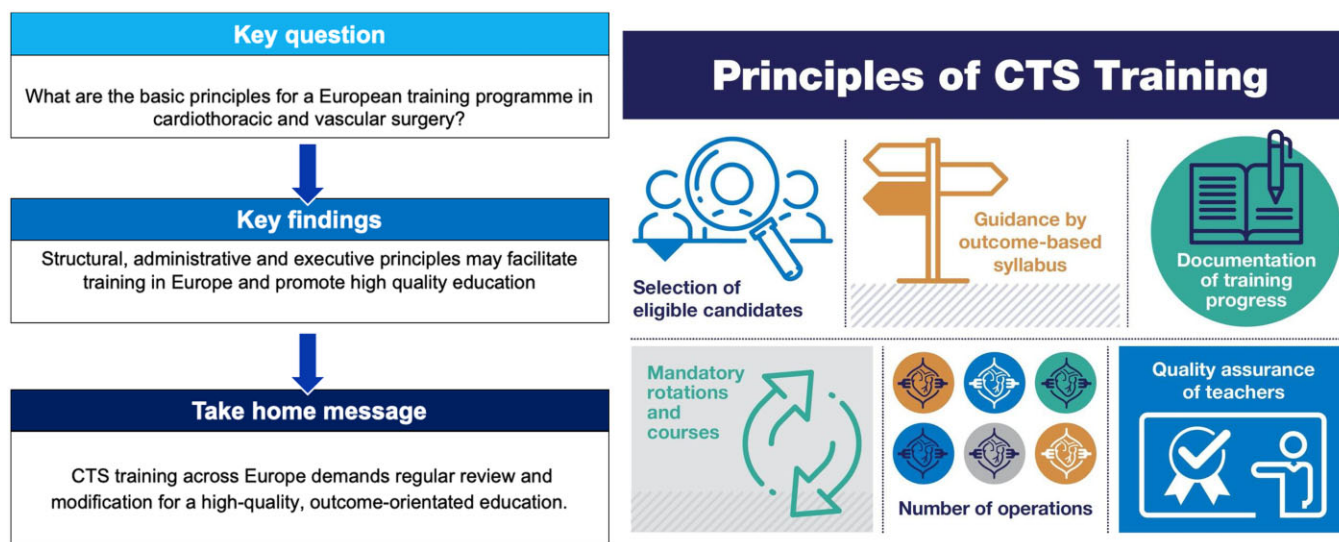
Basic principles of cardiothoracic surgery training: a position paper by the European Association for Cardiothoracic Surgery Residents Committee

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Abstract

OBJECTIVES: Across Europe there are significant variations in the fundamental structure and content of cardiothoracic surgery (CTS) training programmes. Previous efforts have been made to introduce a Unified European Training System, which outlined the fundamentals of

the ideal programme and supported a paradigm shift from an apprenticeship to a competency-based model. This article's goal was to define key structural, administrative and executive details of such a programme to lay the foundations for the standardization of cardiothoracic surgical training across Europe.

METHODS: The European Association for Cardiothoracic Surgery Residents Committee had previously conducted a residents' training survey across Europe in 2020. Training curricula from the twelve most represented countries across Europe were either searched online or obtained from the countries' national trainee representative and reviewed by the committee. Information was collated and placed into one of the following categories to develop the position paper: (i) selection of eligible candidates, (ii) guidance for an outcome-based syllabus, (iii) documentation and evaluation of training progress, (iv) mandatory rotations and training courses, (v) number of independent or assisted cases and (vi) requirements and quality assurance of teachers.

RESULTS: An independent professional body should promote an outcome-based syllabus and take responsibility for the training programme's quality assurance. Trainees should be selected on merit by an open and transparent process. Training should be delivered within a defined period and supervised by an appointed training committee to ensure its implementation. This committee should review the trainees progression regularly, provide feedback and offer trainees the opportunity to experience various training environments and trainers. A common electronic portal be used by trainees to record their agreed objectives and to evidence their completion. Trainees should regularly attend specialty-relevant courses and conferences to promote professional and academic development. The end of training is reached when the formal requirements of the training programme are met and the trainee is able to perform at the level expected of a day-1 independent surgeon.

CONCLUSIONS: This article defines the key structural, administrative, and executive principles for CTS training. Programmes are encouraged to review and modify their training curricula, if necessary, to ensure the delivery of high-quality, standardized, outcome-orientated CTS training across Europe.

Keywords: Cardiothoracic surgery training • European training programme • Education • Residents • European Board examination

ABBREVIATIONS

AMs	Active members
CT	Cardiothoracic
CTS	Cardiothoracic surgery
EACTS	European Association for Cardiothoracic Surgery
EBCTS	European Board of Cardiothoracic Surgery
JCs	Junior committee chairs

INTRODUCTION

Cardiothoracic computed tomography (CT) and cardiovascular surgery is an ever developing and innovative surgical specialization. This coupled with differences in the medical specialization and accreditation systems in European countries has contributed to the current lack of uniformity in CT training [1–3]. Across Europe there are significant variations in the fundamental structure and requirements to achieve certification in CT surgery. Consequently, this impairs surgeon mobility, the exchange of knowledge and skills, benchmarking, external evaluation and transparency [3]. The introduction of the European Board of Cardiothoracic Surgery (EBCTS) examination for a standardized high-level certification has been a step forward, but its role within different national training programmes needs to be defined and anchored with time [3].

Previous efforts have been made to introduce a Unified European Training System which outlined the fundamentals of the ideal programme and supported a paradigm shift from an apprenticeship to a competency-based model [3]. This article's goal was to define key structural, administrative and executive details of such a programme to lay the foundations for the

standardization of cardiothoracic surgery (CTS) training across Europe.

METHODS

The European Association for Cardiothoracic Surgery (EACTS) Residents Committee had previously conducted a residents' training survey across Europe in 2020. Trainees from 24 different European countries participated in the survey with the most respondents from the following countries in a descending order: Germany, France, Portugal, Italy, Switzerland, Belgium, Sweden, Denmark, Finland, Great Britain, Austria and Netherlands. Training curricula from these 12 most represented countries were either searched online or obtained from the countries' national trainee representative and reviewed by the committee. Information was collated and placed into one of the following categories to develop the position paper: (i) selection of eligible candidates, (ii) guidance for an outcome-based syllabus, (iii) documentation and evaluation of training progress, (iv) mandatory rotations and training courses, (v) number of independent or assisted cases and (vi) requirements and quality assurance of teachers.

These categories were discussed in the residents committee consisting of former and/or active junior committee chairs (JCs) and/or active members (AMs) of their national societies [Austria: Can Gollman (JC), Leo Pölzl and Felix Nägele (AMs), Switzerland: Alicja Zientara (JC), Portugal: Rui Cerqueira (JC), Germany: Josephina Haunschild (JC) and Fabian Dörr (AM), UK: Nabil Hussein, Vinci Naruka, Chris Bond and Omar Jarral (AMs), Netherlands: Kirolos Jacob (AM) and France: Maroua Eid (AM)]. Considerations included the duration of training, the practicalities of implementation and national limitations of case numbers and training positions. All were discussed until

an agreement was reached across the committee. The article has been reviewed and adjusted by the senior author J. Rafael Sádaba, chair of education committee of the EACTS and a former member of the previous residents committee of the EACTS.

Case numbers

The required number of cases to have been performed during training should range between 150 and 250 as the primary operator in the trainees chosen subspecialty (i.e. cardiac, thoracic surgery). Although there is no consensus on specific case number, a wide range is recommended which takes into consideration the differences in the structure of training departments and national healthcare systems. Previous studies have shown that the definition of a “case” can vary considerably; however, this should be defined as the trainee performing the majority of the procedure as the primary operator (i.e. coronary artery bypass surgery—set-up and establishment of cardiopulmonary bypass, >75% anastomosis, decannulation and closure; lobectomy—access to pleural cavity, dissection and division of hilar structures, retrieval of lobe, lymph node dissection and closure) [4].

BASIC PRINCIPLES OF CTS TRAINING

Professional body

1. An independent professional body should take responsibility for training programmes' quality assurance. Training programmes should be delivered and regulated at a national or regional level under supervision by an external steering professional body.
2. The professional body must perform at least annual quality assurance of training programmes and trainers. We recommend that formal external evaluation procedures are implemented, including local interviews with trainees and trainers focused on training governance and the assessment of training opportunities. Both quantitative and qualitative data should be collected. Outcomes from these evaluations should be kept anonymous and not impact individual trainees' evaluation or career progression.
3. The professional body should have authority to annually revise and grant accreditation to training centres and trainers.
4. It is recommended that the professional body certifies the completion of training after trainees have graduated and demonstrated competency in their chosen speciality (i.e. cardiac, vascular or thoracic surgery or any combination of the 3).

Surgical curriculum and operative competencies

1. It is recommended that the training of residents is guided by an outcome-based syllabus.
2. The syllabus should contain modules in the core topics of cardiac, thoracic and vascular surgery. For reference this structure is already outlined within the UK's CT training curriculum (e.g. Curriculum Cardiothoracic Surgery [5-7]).
3. Training should be divided into different modules based on complexity (i.e. introductory, intermediate and advanced stages) with trainees progressing through each stage during training. On completion of the advanced module, the trainee would be expected to perform at the level of an independent surgeon performing an index operation in their chose speciality [8].
4. A recommended list of module topics is given in Table 1. The specific module areas should be adapted to the specific needs of

Table 1: Online sources of national training catalogues represented by the 12 countries with the highest rate of respondents in the residents' survey of 2020

Country	Online source: current national syllabus for cardiothoracic surgery
Germany	https://www.bundesaeztekammer.de/fileadmin/user_upload/downloads/MLogbuch-7.3-FA_Herzchirurgie.pdf
France	Société Française de Chirurgie Thoracique et Cardio-Vasculaire https://www.sfctcv.org/formation/des-ctcv/
Portugal	https://dre.pt/dre/detalhe/portaria/825-2010-343924
Italy	Ministero dell'Istruzione Decreto interministeriale recante gli standard, i requisiti e gli indicatori di attività formativa e assistenziale delle Scuole di specializzazione di area sanitaria https://www.miur.gov.it/-/decreto-interministeriale-recante-gli-standard-i-requisiti-e-gli-indicatori-di-attivita-formativa-e-assistenziale-delle-scuole-di-specializzazione-di-
Switzerland	Facharzt für Herz- und thorakale Gefäß- chirurgie https://www.siwf.ch/files/pdf25/herz_thorakale_gefasschirurgie_version_internet_d.pdf
Belgium	Belgische Vereniging Voor Cardio-Thoracale Heelkunde https://www.bacts.org/#real_content
Sweden	Online resource not available
Denmark	https://thoraxkirurgi.dk/wp-content/uploads/M%C3%A5lbeskrivelse-for-thoraxkirurgi-2014.pdf
Finland	Ammatillisen jatkokoulutuksen opinto-oppaat https://www.laaketieteelliset.fi/ammattillinen-jatkokoulutus/opinto-oppaat#erikoislaakarikoulutus-1
Great Britain and Ireland	The Intercollegiate Surgical Curriculum Programme—Cardiothoracic surgery curriculum https://www.iscp.ac.uk/media/1108/cardiothoracic-surgery-curriculum-aug-2021-approved-oct-20.pdf
Austria	Online resource not available
Netherlands	Opleiding Cardiothoracale Chirurgie - Curriculum Van De Opleiding Tot Cardiothoracale Chirurgie https://www.nvtnet.nl/sites/thorax.productie.medonline.nl/files/bijlagen/Opleidingsplan%20Cardiothoracale%20Chirurgie%202020.pdf

Most of the recommendations are formulated in the national language.

- individual countries' training programmes. This position paper focuses on CTS-specific topics. Non-technical skills are crucial for CTS training and are described elsewhere [9].
- The syllabus should be reviewed and updated regularly to incorporate emerging technologies and recent changes in evidence/guidelines. This will encourage the development of versatile and innovative surgeons [10].
 - Supplementary modules should be available in relevant allied specialty areas. Given the degree of interdisciplinary work central to the modern practice of CT and cardiovascular surgery, it is strongly recommended that trainees are allowed to participate in learning opportunities in the following areas early in their programme: cardiology, pneumology, radiology, general surgery, anaesthesiology and critical care.

Fundamental capabilities

- Prior to certification, trainees must reach competency in the index procedures of their chosen specialty (Figures 1 and 2). Typically, these procedures should be able to be performed fluently with the ability to anticipate, avoid and/or deal with common problems.
 - Trainees must document their operative history in their portfolio through their work-based assessments and logbook.
- It is recommended that programmes set a predefined number of first operator cases required to finish training; typically set at a minimum of 150–250 cases. A 'first operator case' is one where both the majority and the main components of the procedure are performed by the trainee [5, 11].
 - It is recommended that at least 10% of cases (i.e. 15–25) should be performed independently. Independence is defined as the absence of an attending surgeon from the operating theatre [5].
 - It is recommended that 10% of cases (i.e. 15–25) should include advanced procedures outside of the index procedures (e.g. mitral valve repair or sleeve resection) [12].

Programme delivery

- Duration of training should be determined by the expected period required for a trainee to become a competent cardiac, thoracic and/or vascular surgeon capable of independent practice throughout Europe's diverse health systems. This period will depend on factors including expected case volume, the training ethos and trainee aptitude. It is expected that a training programme will last no less than 5 years and not exceed 8 years.
- The programme should be supervised by a training committee who organize the delivery of training for each trainee and ensure its implementation. This committee will ideally consist of a group of cardiac, vascular and thoracic surgeons who are recognized

Recommended curriculum module topics

Cardiac	Vascular	Thoracic
Critical care and post-operative management		
CPB, myocardial protection and circulatory support	Thoracic aortic disease (aneurysms and dissections)	Neoplasms of the lung
Ischaemic heart disease/ CAD	Abdominal aortic disease	Disorders of the pleura
Valve disease	Endovascular therapy	Disorders of the chest wall
Aorto-vascular disease	Cerebrovascular disease	Disorders of the diaphragm
Transplantation and surgery for heart failure	Renovascular disease	Emphysema
Congenital heart disease	Peripheral artery disease and infra inguinal bypass surgery	Disorders of the pericardium
Trauma	Amputation and debridement	Disorders of the mediastinum
Transcatheter intervention	Vascular Trauma	Disorders of the airway
Academic cardiac surgery	Varicose vein surgery	Esophageal disease (malignant and benign) *
	Hemodialysis access	Academic thoracic surgery

Figure 1: Recommended curriculum module topics; *country dependent. CAD: coronary artery disease; CPB: cardiopulmonary bypass.

Definition of index procedures	
Cardiac	AVR, CABG, Combined AVR + CABG, ECMO
Thoracic	Anatomical lung resection, decortication, pneumothorax surgery, sleeve resection, uni- / bi- / triportal VATS and robotically assisted procedures
Vascular	Carotid endarterectomy, haemodialysis access, open aortic procedures for aneurysmatic disease, reconstruction of femoral vessels, infra-inguinal revascularisation for peripheral arterial disease, peripheral embolectomy, varicose vein surgery, amputations, EVAR

Figure 2: Definition of index procedures. AVR: aortic valve replacement; CABG: coronary artery bypass grafts; ECMO: extracorporeal membranous oxygenation; EVAR: endovascular aneurysm repair; VATS: video-assisted thoracoscopic surgery.

members of their respective national or local professional bodies. Their responsibilities include regular review of each trainee's progress, the opportunities and quality of the training delivered by the units. This review should be data driven by examining the overall case volume of the unit, the volume the trainee is exposed to and their case numbers. Ideally, the risk profile of these cases should be assessed by a recognized scoring system (e.g. EuroSCORE II). The training committee is also responsible for tracking the progress of trainees throughout their training. This includes identifying trainees who are undergoing difficulties, understanding the reasons and instituting an appropriate action plan in a timely manner.

3. Training programmes should be compliant with equal opportunity legislation and meet all of its requirements [13, 14] (<https://fra.europa.eu/en/eu-charter/article/21-non-discrimination>).
4. Simulation-based training has proven to be useful adjunct to traditional surgical training in particular in the acquisition of technical and non-technical skills. If possible these methods should be incorporated into training programmes. Simulation offers a low-pressure learning environment in which trainees can develop their technical skills, which will better prepare them for real-life operating. In addition to assisting with hand-dexterity, fluency and operative sequencing, it also allows surgeons to rehearse rare surgical emergencies, where clarity of thought and efficiency are crucial to mitigate any adverse consequences (i.e. massive air embolism). Training programmes should work to incorporate these benefits where possible [15].

Trainees

1. Trainees should be selected on merit by an open and transparent process. Several countries have adopted a national selection process to overcome perceived local bias. Ideally, such national selection processes should be standardized, reviewed annually and adjusted accordingly. The interview process may be conducted by a national recruitment team or a panel consisting of the senior surgeons responsible for the local training programme to avoid the bias of candidate selection. Clear applicant instructions should be provided [5]. Selection criteria should cover all skills and attribute pertinent to a career in CT and/or cardiovascular surgery, including non-technical skills. These skills and attributes may be assessed via a structured application form and standardized, structured interview [5].

2. A process of workforce planning is recommended to project the future demand for CT surgeons, which will assist the appropriate allocation of training positions to meet future need. This will promote the efficient use of resources and prevent the risk of a bottleneck for consultant positions on training completion.

Rotations

1. Each training hospital within the training programme should have appointed trainers who will take primary responsibility of trainees, ensure their training and that they are working towards their agreed objectives.
2. If possible, trainees should be encouraged to work with different trainers across a number of training environments/units to gain a breath of operative/clinical experience and maximize their teaching opportunities.
3. Each training centre within a region should agree to use a common assessment/portfolio portal to provide training transparency and assist with quality assurance. This will assist with programme evaluation and trainee/unit comparison.

Portfolio

1. A common portal should be used for trainees to record their agreed objectives and evidence as they progress through training [16] (reference of an example online logbook used in the UK and internationally by EACTS: <https://www.elogbook.org>, <https://training.eacts.org>).
2. Evidence should primarily include operative logbooks, assessments on procedural/clinical skills, case discussions and teaching as outlined by the curriculum.
3. These assessments should be validated by the trainers at the time of performance to ensure accurate feedback is given.
4. Trainees should also upload evidence of achievements outside of their daily clinical practice to demonstrate commitment to continued professional development. This includes: audit/quality improvement, awards/prizes, completion of examinations/courses, journal publications, presentations (local, national and international), conferences/meetings attended and research.
5. Teamwork and leadership skills should be trained and validated regularly [17, 18].
6. Trainees' portfolios should contain a logbook, an up-to-date CV and be reviewed periodically by a responsible mentor.

Performance review and feedback

1. Trainee reviews should be undertaken at least once per year by either the appointed national training panel or the local training committee. This review is a structured meeting between the training panel and trainee to reflect on their training and progress throughout the programme.
2. The training panel should initially review the trainees' portfolio evidence, logbook and feedback over the period since their last meeting independently and then meet with the trainee. The panel should use this meeting to evaluate the trainee's overall progression and ensure they are on course to meet the curriculum objectives.
3. The Objective Structured Assessment of Technical Skills is a structured way of assessing manual dexterity of trainees and the practical implementation of operative techniques [19, 20]. This encompasses areas such as tissue handling, timing and movements, handling of instruments, instrument knowledge, progress of the operation and knowledge of the procedure. It is recommended to incorporate such Objective Structured Assessment of Technical Skills forms or performance-based assessments and for trainees/trainers to complete these shortly after each operation performed. Trainees should aim to complete at least 1 objective assessment per month with a minimum of 8 per year.
4. Performance reviews should provide an opportunity for confidential trainee feedback to promote openness and fairness.
5. The contents of all reviews should be documented and kept confidential unless there are concerns raised which may impact trainee, trainer or patient welfare.
6. If there have been any significant events, complaints or other investigations involving the trainee since their last review then these should be declared to the training panel and discussed if appropriate.
7. A written report is made of the above-mentioned assessment interviews, which is agreed and signed by both the trainer and trainee. This report will also include the training objectives for the upcoming year.

Training courses and international conferences

1. The courses "Fundamentals in Cardiac Surgery I, II, III" for cardiac trainees and "Fundamentals in Thoracic Surgery I, II, III" for thoracic trainees offered by the EACTS are a valuable resource to improve training and are therefore recommended for every CTS trainee (www.eacts.org/educational-events/academy/).
2. Regular contributions and visits to international conferences (e.g. EACTS Annual Meeting) are recommended to promote scientific and personal exchange with fellow trainees, senior surgeons and allied health professionals.

Completion of training

1. It is recommended that surgical training is outcome and competency based. The end of training is reached when the trainee is able to demonstrate that they have the clinical, academic and surgical competencies required to work as a day-1 independent consultant in their chosen speciality. This will include evidence of completion of the required examination, competency sign-off from their respective training centres/trainers and achievement

of the minimum number of independent cases. It is desirable that trainees also demonstrate a commitment to academia, leadership, management and teamworking, which are important non-technical skills required in CT surgeons.

2. Once signed off by the training committee, the trainee should be supported in their application for the national board certificate which is usually regulated by the responsible national medical council.
3. The evaluation of competency as an independent operator in the index procedures will vary between training programmes. This can be assessed by the number of case numbers performed by the trainee during the programme or in special circumstances via a practical examination such as performing a standard operative case in front of a panel.
4. The EBCTS examination has become an important European standard in CT surgery training. It is recommended that trainees complete part 1 The Membership of the European Board of Cardiothoracic Surgery (MEBCTS) after finalizing the national training. The aim is to conduct this examination within the last 2 years of residency when a trainee has performed ~100 open heart surgeries or 100 thoracic procedures and has completed the requirements of their respective national specialty register. In few countries (i.e. Switzerland, Finland), the MEBCTS is carried out before the trainee can receive their national board certificate as the European exam serves here as a national equivalent for a theoretical exam.

PURPOSE AND FUTURE PERSPECTIVE

The summary of the basic principles in CTS training has been researched and established by the members of the current EACTS Residents Committee based on the different training systems across Europe. This include well-structured programmes requiring mandatory modules and examinations but also programmes that allowed more flexibility in terms of rotations and career changes. Different education programmes for CT surgery exist across Europe and every year successful graduates of national CT training start their work as independent surgeons. Therefore, there is no right or wrong training programme in the development of independent surgeons; however, uniformity is encouraged to promote training transparency, comparison and evolution. For the first time in a generation, the European Board examination offers trainees and excellent opportunity to achieve a qualification that may become valid across national borders and serve as a quality brand for the training in a European country.

The purpose of the article was to create a document to help guide training programmes in the delivery of high-quality training of current and future CT surgeons. This article will require regular update and is flexible to evolve over time without forcing departments into regulations that cannot be achieved due to political, financial or structural constraints. Both well-established and less-structured training programmes are encouraged to review their current curricula and if necessary introduce modifications to promote the delivery of high-quality, outcome-orientated training of their trainees.

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The previous EACTS Resident Committees made the first steps towards a unified training programme, shared new developments and international surveys and introduced the idea of a standardized

training in Europe. Their inspiration and support remain in our work and pave the way in our goal to improve trainee education and experience in CT surgery.

Conflict of interest: none declared.

Author contributions

All authors have substantially contributed to the drafting of the manuscript and its contents.

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