Cardiac surgery

The Society for
Cardiothoracic Surgery
in Great Britain and Ireland

National Cardiac Surgery Activity and Outcomes Report 2002–2016

Prepared by

Stuart W Grant MBChB (Hons), MRCS, PhD
David P Jenkins MS (Lond), FRCS (CTh)

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Heart Research UK

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Foreword from the President

This book is unique in that it represents the UK's entire cardiac surgical activity over 15 years. No other nation or specialty has such a complete dataset over such an extended period.

Every one of these 500,000 heart operations is where individuals have put their trust in the surgical team: to get them through surgery safely; to improve their symptoms; to improve their quality of life; to prolong their life. Every patient has great courage to consent to have their heart operation.

This book shows that all the cardiac surgical teams in the nation have accepted their responsibility to be accountable to the patients they serve, the vast majority of whom are treated by the National Health Service. Those teams have embraced the mantra that professionals should 'know how much they do and how well they do it'. Furthermore, this audit is associated with significant improvement in survival over those 15 years, which is better than other national audits, despite the patients being older and frailer at the time of their surgery. Looking forwards, there can be justified optimism that reporting of outcome measures beyond survival will result in further quality improvement. The challenge is to continue to build on this success in the future.

Finally, this book is about acknowledging the whole team: everyone involved in the patient pathway should be very proud to be part of a national programme of heart surgery that is producing such high levels of survival. The skills of the surgeon are important but the surgeon cannot be successful in isolation. Good outcomes are dependent on so many more professionals, before, during and after the surgery.

In recognition of this teamwork, this introductory section includes contributions from the national leaders of cardiology, cardiac anaesthesia and intensive care, cardiopulmonary perfusion and the allied health professions. Together we represent the key roles that deliver the service, and by working together professionally and effectively, we will continue to improve.

The cardiac surgical audit in the UK and Ireland assures patients that they are receiving consistent world class care.

Mr Simon Kendall
President, SCTS

Invited commentaries

The value of recording and publishing data on cardiac surgical procedures has long been recognised by the NHS, and the release of this new version of the Blue Book is welcome. This book is without parallel in the world, and it is a credit to the work of the SCTS, individual surgeons and allied professionals who have submitted the data.

The report highlights the reduction in mortality for all cardiac surgical procedures despite dealing with an older population with more comorbidities. This is not only due to the surgeons but also to the other members of the multidisciplinary team who look after the patient from before surgery to postoperative rehabilitation. The results displayed in this report are among the best in the world, and I am optimistic that the improvement in outcomes and care will continue.

I am keen that going forwards we continue to focus on the team approach to patient management and looking at other quality indicators beyond survival.

Professor Nick Linker
National Clinical Director for Heart Disease, NHS England and NHS Improvement

This latest Blue Book is remarkable in a number of ways. It is unique in providing a comprehensive, longitudinal description of cardiac surgical activities in the UK and Ireland. Furthermore, it highlights beautifully the advances in clinical practice and improvements in outcomes, which have been achieved even in patient populations of increasing risk due to older age and comorbidities. It also demonstrates the added value of the use of data analysis to deliver quality improvement.

The SCTS has been part of the National Institute for Cardiovascular Outcomes Research (NICOR), which has 'joined up' reporting of multiple cardiovascular outcomes, and has been at the forefront of a number of significant developments, including risk-adjusted reporting, individual operator performance and provision of understandable information to the public. This has played a major role in public confidence and trust in the medical profession, even beyond cardiac surgery.

The cardiac surgical community continues to innovate in the way in which data are collected and reported. Cardiac surgeons are increasingly part of a complex, broad medical team and outcomes do not just depend on the skill of the surgeon. Good decision making before surgery as well as teamwork to deliver excellence both before and after an operation are crucial. As NICOR evolves, there will be more opportunities to understand and report underlying cardiovascular diseases and their treatment. The SCTS deserves great credit for its achievements detailed in this Blue Book, which place the UK at the forefront of cardiac surgery, both in care delivery and reporting.

Professor John Deanfield
Director, NICOR

NICOR

The SCTS is to be congratulated on the publication of this comprehensive report. It covers a period of time during which practice has evolved at an unprecedented rate, with the expansion of percutaneous coronary intervention and the development of transcatheter aortic valve implantation having a significant impact.

From the perspective of a cardiologist, it is important to recognise that operative mortality continues to decline across the breadth of cardiac surgery despite an increase in the complexity of the patients coming to operation. This recognition is fundamental to decision making in our complex clinical environment, where collectively, we have an array of interventions, all subject to systematic audit, that can be applied to the benefit of individual patients. I would also like to endorse the view expressed in the concluding paragraph of the report that monitoring of performance has to continue to evolve and that surgeon-specific survival may not be the best driver of further improvement in an era where the outcome of any complex intervention is increasingly reliant on the close collaboration of a range of healthcare professionals.

For 20 years, the SCTS has been at the forefront of quality improvement in cardiac surgery and I am confident that this will continue into the next decade.

Professor Simon Ray
President, British Cardiovascular Society

The SCTS and more particularly its membership should be congratulated on what is an outstanding achievement in collecting and collating the data required to produce this book. The SCTS has led the country and the world in collecting data on surgical outcomes, which can be traced back to individual surgeons, and then putting this information in the public domain, thereby creating a real daily pressure on individual surgeons to ensure their results do not stray outside the statistical limits of good practice.

There is no doubt that this has partly reduced mortality but it also created the possibility that high-risk patients might be turned down for surgery because of the potential impact an adverse outcome could have on results. More recently, steps have been taken to mitigate that risk.

I would suggest that the continuing improvement in patient outcomes in cardiac surgery is not solely down to the pressure of publishing the results of individuals. Instead, it is due partly to increased focus on the detail of all aspects of the patient pathway by every member of the multidisciplinary team to eliminate any events or practices that may lead to an adverse outcome.

The challenge is to continue to build on the success this book represents, which may mean shifting the focus of outcomes data collection more on to the team or the unit rather than the individual. This will involve the Association for Cardiothoracic Anaesthesia and Critical Care and its members engaging both nationally and locally with all members of the multidisciplinary team so that the ownership of responsibility for outcomes lies with the whole team rather than with a single individual.

Dr Niall O'Keeffe
President, Association for Cardiothoracic Anaesthesia and Critical Care

The audit findings presented in this Blue Book clearly illustrate how much surgical outcomes in the specialty have improved despite the changing patient demographics and the increasing complexity of treatment options. Over the last 15 years, there have been significant changes in the way nurses and allied health professionals work, learning new skills and acquiring knowledge and education to equip practitioners to adopt roles that have traditionally been in the medical domain. Not only has this provided a career pathway to progress at a clinical level but notably, it has also had a positive impact on patient experience, patient outcome and patient safety.

The SCTS has long been associated with recognising the contribution of nurses and allied health professionals in patient outcomes, and it has been a powerful advocate in supporting new ways of working through access to education, research and multidisciplinary networking. Nurses and allied health professionals are now fully integrated into the SCTS, and are able to share practices and ideas widely through the members' forum.

We should all feel exceptionally proud to be part of a specialty that is truly collaborative and really encompasses the term 'multidisciplinary team', where all roles are valued to achieve a common goal, in which the patient is central. As we strive to improve further, it is hoped that future audits will include outcomes that can be directly attributed to nurses and allied health professionals so that we can assure our patients that they will continue to receive the best possible care.

Mrs Helen Munday
Lead for Allied Health Professionals, SCTS

The results in this Blue Book are extremely positive and demonstrate all that has been achieved in the field of cardiac surgery throughout the UK and Ireland. This current publication serves as a paradigm to the clinical perfusion science profession, and it is a wonderful example of how datasets and reporting can be used to enhance or highlight areas of focus for the future.

The increasing demand for digitalisation and measuring outcomes is evident across the whole spectrum of healthcare. Clinical perfusion science is uniquely placed as it is one of the few specialties with access to real-time data that could potentially be used to inform techniques and change outcomes.

It is heartening to see acknowledgement of the importance of the contribution and collaboration of the extended heart team. It is essential that all groups have a shared responsibility as well as being individually accountable for patient outcomes.

The last 15 years have seen many changes in patient demographics and surgical approaches, and interprofessional collaborative practice in the future will be key in the continued delivery of better patient outcomes. It is crucial that there is a mutual respect among all cardiac perioperative professionals to ensure that the cardiac surgical team can form a shared vision that is collaborative and driven by safety, outcomes and data as we can all recognise that the best overall outcome for a patient is achieved by the whole team working closely together.

Mr Noel Kelleher
Chair, Society of Clinical Perfusion Scientists of Great Britain and Ireland

I am delighted to have been asked to write a commentary on this Blue Book, which charts the progress of patient centric care and greater teamwork over many years. The inclusion of this piece bears witness in a small way to that – the research in the book speaks for itself.

Data are hugely powerful because they show the medical professions whether they are doing the patient any good. The significance of the latest edition of the Blue Book is that it contains data for 15 continuous years of cardiac surgical activity in the UK and Ireland, and as such, it charts the advances in clinical practice and the improvements in patient outcomes. It is a valuable source of information, and despite patients being older and having multiple issues, the outcomes are getting better all the time.

This gives us hope: hope for patients now and in the future. It also gives us confidence, to want more.

Collaborative teamwork has been shown to be key to successful outcomes, something that patients have known for years. It will continue to be pivotal to ensuring better outcomes and raising the standard of care in the future. However, one team member is consistently missing: the patient. The profession is still learning what 'patient involvement' really means and that it is not only at a patient/practitioner level that patients should be involved.

For there to be real meaningful progress in patient care, patients and the public should be included in all organisations and teams, and play a full part in their decisions. Only when we are an equal member of the team will we be able to influence patient centric change for the better.

There is no doubt that this book is a significant piece of work and the SCTS should be justly proud of leading the way in this field. Nevertheless, it cannot and must not rest on its laurels. It has given us the data and it behoves us to use it to improve the future. We now want the important improvements in the quality of life after surgery.

I would urge every cardiac charity and patient group to exploit the contents of the Blue Book to the full and drive ever greater improvement in the patient experience, pushing for patient representation in all organisations and teams. We are all potentially patients; it is our future and we are not sitting on the sidelines.

Mrs Sarah Murray
Lay Representative, SCTS, and Chair of the Patient Representative Group, NICOR

Executive summary

David P Jenkins

It is with great pleasure that I write this editor's summary to the latest edition in the SCTS cardiac surgery Blue Book series. Some may not be familiar with the origin of the term 'blue book', which predates the SCTS and even cardiac surgery. It actually derives from the 15th century, when blue coloured books were used to record events in Parliament. Since then, the term has been used to describe books that compile information and statistics so the original adoption of the term for this series was apt.

This latest edition of the SCTS Blue book is different from previous publications, the last of which was a collaboration between the SCTS and Dendrite Clinical Systems, published back in 2008. At that time, data were still uploaded to the Central Cardiac Audit Database and the National Institute for Cardiovascular Outcomes Research (NICOR) was just being developed at University College London. Since then, an online edition of the Blue Book, aimed primarily at patients, was published by NICOR in 2011.

At this point, it is important to recognise NICOR and the forethought and energy of previous Blue Book editors, Sir Bruce Keogh and Ben Bridgewater, who were instrumental in pushing the boundaries of data collection and reporting at what was a pivotal time for cardiac surgery. It is also critical to recognise the contribution of risk scoring systems that we now take for granted but without which we would have less understanding of the progress we have made.

Finally, it remains crucial that we continue to share our data with each other and our patients. My colleague Samer Nashef gave his book, *The Naked Surgeon* (which aimed to educate the public about these complex issues), the subtitle of 'How the new science of transparency is revolutionising medicine'. We should all be proud that cardiac surgery helped start the revolution.

In this latest version, I wanted something different from previous Blue books, to review the national perspective over a longer timeframe to investigate trends rather than concentrating on individual or unit comparative performance over a three-year period. It is also very much an SCTS publication as we did not have the resources available from which previous Blue Books benefited. We were fortunate to get a grant from Heart Research UK to pay for the data extraction and analysis from NICOR whereas the clinical authors and editors generously gave their time without remuneration. This was inevitably more of a challenge and took longer than anticipated but I hope you agree that it was worth the wait as we have analysed over half a million cardiac surgery operations.

The original plan was to look at the first 15 years of the new century, a time of rapid expansion of percutaneous coronary intervention and the introduction of transcatheter aortic valve implantation, but the eagle eyed will spot that the data actually represent 14 complete financial years. We also wanted to cover the whole breadth of cardiac surgery while highlighting specific important subsets such as surgery in older patients and aortic surgery.

Inevitably, there are a number of limitations to this report. My main regrets are related to data completeness and links to other databases. The data quality on morbidity is not as good as for other fields and as mortality decreases, we should focus more on other outcome measures to improve future quality of care. At present, it is not possible to link our NICOR data to the Office for National Statistics to estimate long-term survival – even though this was allowed in the past! As we increasingly compare our operative results with so called less invasive treatments (e.g. percutaneous coronary intervention and transcatheter aortic valve implantation), we need to look at survival five years or more after surgery, not just at what happens during the hospital admission. Our surgical patients take their risks up front and gain the full benefits much later.

The summary is that we as the surgical community have adapted successfully to changing patient demographics and demands, and we continue to improve:

- We have analysed 534,067 operations from an average of 40 contributing hospitals, with more consultant surgeons (increase from 219 to 278), each doing fewer operations but with better results.
- Although our patients have aged (by an average of 2 years) and their risk profile has increased (from a logistic EuroSCORE [European System for Cardiac Operative Risk Evaluation] of 5.6 to 8.5), more survive surgery. Indeed, the crude mean in-hospital mortality rate has fallen from 4.0% to 2.8% during this era.
- We are undertaking proportionally more complex combined operations but fewer redo procedures.
- We have performed a consistent amount of emergency surgery but the proportion of elective cases has fallen in favour of more urgent surgery (at same hospital admission) taking place (increase in proportion of workload from 23% to 31%).
- We are operating on older patients; those aged >70 years make up >40% of our current workload but the biggest change has been in those aged >80 years (increase in proportion of workload from 4% to 11%).
- These trends are illustrated by the coronary artery bypass graft (CABG) data. We are doing fewer isolated CABG procedures (a reduction of a third over the period reviewed) as the ratio of percutaneous coronary intervention to surgery has steadily climbed. However, the results for those who still require CABG are excellent, with the mortality rate for elective isolated CABG surgery now at 0.6%.
- Valve surgery has seen a relative and absolute increase in activity commensurate with the older population referred for surgery. Aortic valve surgery accounted for over a third of our workload at the end of the period analysed in this Blue Book, compared with a fifth at the beginning. This is despite the rapid increase in transcatheter aortic valve implantation activity since 2007. There has been a 50% reduction in mortality for isolated aortic valve replacement (in all urgency categories) from 3.6% to 1.7%.
- Mitral valve surgery increased during the first half of the period reviewed and has been consistent in the second half. The majority of mitral valve surgery remains elective and a higher proportion of patients now receive a repair (>60%) rather than a replacement. The mortality rate for elective mitral valve repair has reduced but is still 1.7%, higher than for elective CABG and for elective aortic valve surgery.
- Major thoracic aortic procedures have doubled during the era of this study, with

>1,250 performed in the final year of this period. However, relative to the US and Europe, we still perform fewer aortic surgical procedures in the UK and Ireland. The results of surgery for all groups (apart from emergency operations) have improved with a mortality rate of <4% for elective major aortic surgery.

None of these achievements would have been possible without the dedication of the whole multidisciplinary team looking after the patients described in this report. This success is the sum total of millions of individual patient interactions by so many team members but every one is critical to delivering the very best outcomes. Despite the remarkable improvements, I sincerely believe that by optimising every single patient event, the results of cardiac surgery in the next 15 years will be better still.

I want to personally thank all those clinicians, data managers and audit leads who have spent endless hours inputting these data because without their efforts, we would not have such a comprehensive story to report today. The completeness and accuracy of the source data is critical for future Blue Books, and it remains our responsibility to ensure this.

I would also like to thank four SCTS presidents who supported and encouraged me during my time as chair of the SCTS audit committee: Tim Graham, Graham Cooper, Richard Page and Simon Kendall. Further specific thanks are justified to my co-editor, Stuart Grant, who has so generously provided his expertise and time, and also to our excellent copy editor, Tara Nikovskis, whose influence has made these pages more readable. I also want to acknowledge the work of Heart Research UK, who provided the research grant that enabled this work.

Chapter 1: Introduction to data collection and reporting

Andrew Goodwin and Uday Trivedi

1.1 History of cardiac surgery data collection

Since Sir Terence English (subsequently President of the Royal College of Surgeons of England) set up the UK Cardiac Surgical Register 43 years ago in 1977, cardiac surgeons in the UK have led the way among doctors, both nationally and internationally, in collecting and analysing data about their specialty. Initially, this initiative simply recorded unit activity levels and mortality rates so as to allow hospitals to compare themselves with each other. Over the first five years (1977–1982), it showed a gradual fall in mortality rates for cardiac surgery, as well as highlighting the rapid growth in coronary artery surgery at that time. It also identified tenfold variations in the levels of provision of cardiac surgery around the UK.[1]

In 1986, the UK Heart Valve Registry was established by Professor Ken Taylor at the Hammersmith Hospital. This collected data from around 60% of valve operations in the UK and tracked mortality rates for nearly 20 years until it was discontinued in 2004. It became an invaluable resource for tracking the performance of different types of heart valve implant over a long follow-up period as many valve implants do not show any problems until ten or more years after their implantation.

The National Adult Cardiac Surgical Database was set up by Professor Sir Bruce Keogh (subsequently President of the SCTS and then Medical Director of the NHS) on behalf of the SCTS in 1994. It was recognised at this time that more detailed data than just simple case numbers and mortality were required. It was planned that, in time, this would replace the Cardiac Surgical Register and the Heart Valve Registry. Detailed patient-specific data were recorded for every operation, including patient demographics and risk factors, as well as procedural information.

The impetus to publish adult cardiac surgery data was precipitated by the publication of the final report of the Bristol Royal Infirmary Inquiry in 2001 (although this inquiry was into deaths after paediatric heart surgery).[2] The introduction of the Freedom of Information Act then prompted the SCTS to work with *The Guardian* to publish surgeon-specific outcomes after adult cardiac surgery for the first time in 2005.[3] This meant that the data carefully collected by individual units and surgeons that had been submitted to the national database were used for the analysis, rather than allowing the newspaper to use alternative data sources collected purely for administrative purposes in the NHS. Without this, it would have been impossible to adequately risk stratify the workloads of the different units and surgeons, which would have been likely to have had an adverse effect on those willing to operate on higher-risk patients.

The SCTS has continued to publish unit/surgeon-specific results on its website since that time. However, the reporting of cardiac outcomes has changed significantly over the past two decades. Surgeon-specific outcomes are now a matter of routine reporting and, with the added sophistication of the dataset, risk-adjusted survival (rather than mortality) is reported on an annual basis covering the previous three years of data for each surgeon and each unit. The complexity of statistical modelling behind the analysis has increased but despite taking the best available statistical advice, the methodology to identify outlying hospitals and surgeons has continued to be a challenge for the profession.

In 2011, the National Institute for Cardiovascular Outcomes Research (NICOR) was created by the amalgamation of six cardiovascular audits in the UK, each of which was run by their own specialist societies. These included the National Adult Cardiac Surgery Audit (NACSA) as well as the congenital audit (NCHDA), the heart attack audit (MINAP), the angioplasty audit (NAPCI), the heart failure audit (NHFA) and the arrhythmia audit (NACRM).

In 2017, NICOR incorporated all six audits into the National Cardiac Audit Programme (NCAP), currently hosted at St Bartholomew's Hospital in London. This is overseen on behalf of NHS England by the Healthcare Quality Improvement Partnership (HQIP) although agreements are in place that allow data collection from all four constituent countries of the UK. An annual joint report across cardiovascular medicine and surgery is published[4] in addition to individual, more detailed reports from the six audit domains. As part of this, the cardiac surgery audit produces the annual Clinical Outcomes Publication with details of outcomes and performance of all units and surgeons in the UK.[5]

1.2 NICOR data collection methodology

The collection and storage of patient data is one of the key functions of NICOR. Each individual hospital is responsible for the collection and accuracy of its own data. This is usually performed by individual surgeons assisted by audit teams in each unit. Most hospitals use proprietary software, or have their own in-house bespoke systems, to collect the data, which can then be uploaded in the required format to the NICOR servers. There is also the facility for direct data entry via a secure web portal. Each variable collected has a strict definition. Data uploads are encouraged to be frequent and timely (usually within a month of an operation), with an absolute deadline for submission by three months following the end of each financial year. The finalised, cleaned and validated dataset is usually ready for analysis around six months after the end of each audit cycle.

Once the data are received at NICOR, they are cleaned according to a published algorithm (removing items such as duplicate entries). A report on the amalgamated data for the past 12 and 36 months is then fed back to each unit with a preliminary analysis to allow internal validation and checking. Any errors can then be rectified before the final analysis is made. Dataset design and data validation are a constantly evolving process. The dataset has developed to accommodate new procedures, new risk models and increasing patient comorbidities. Unlike the smaller congenital database that includes site visits annually, the external validation of adult cardiac surgery data submitted by units remains an elusive goal. Given the resource requirements to provide external validation on a national scale, it is unlikely to happen. Validation remains dependent on units having good internal process and being able to maintain accurate data capture.

For most reports, death within the surgical dataset is defined as an 'in-hospital death' since this is the easiest measure for hospitals to validate. This means the death occurred during the same admission to hospital as the surgical procedure (even if the death occurs more than 30 days following an operation). In the rare cases where two cardiac operations occur during the same admission, the death (and the risk stratification) is attributed to the first operation. Cross-checking of mortality is performed by an analysis linked to the Office for National Statistics (ONS) mortality data (from UK death certificates) and this shows very little discrepancy between a unit's self-reported mortality rate and the ONS data.

1.3 The SCTS Blue Books

Sir Bruce Keogh published the first Blue Book in 1998, reporting on outcomes of adult cardiac surgery. It was the first report on cardiac surgical outcomes that went beyond simple aggregate numbers of cases and included comparisons between hospitals. It was also the first time in the UK that risk-adjusted outcomes were reported at national level. The risk adjustment was only possible by collecting numerous data points on individual patients undergoing cardiac surgery. The report was the first to state the individual and institutional responsibilities, how governance meetings should be conducted and the importance of mandatory collection of surgeon-specific data. Later reports in the Blue Book series focused in more detail on specific demographics and risk factors of cardiac surgery patients as well as differences between units in the UK.

Sir Bruce highlighted a number of issues that would need to be addressed in the coming years: resources, dataset design, data validation, reporting and collaboration. With the passage of over 20 years, some of these matters remain contemporary. Given the budgetary challenges faced by the NHS, cardiac units remain under stress to maintain the resources necessary to collect, internally validate and export the data to external agencies such as NICOR.

In 1998, it was perceived that the data would be used primarily by the Department of Health. The number of organisations that now are involved and/or informed by the data has grown beyond this expectation. The data are used in reports by HQIP and NICOR as well as to inform decision making by the National Institute for Health and Care Excellence and commissioning bodies. Patient representation has been introduced on a number of executive committees in the SCTS and NICOR.

The processes in place to collect these data, their analysis and reporting have acted as a paradigm for many other surgical and medical specialties. This has led to an increasing demand for measuring outcomes across the whole spectrum of healthcare. There is no doubt that such systems of outcomes monitoring have been associated with improved patient outcomes. In adult cardiac surgery in 1993, the mortality rate for all first-time coronary artery bypass graft (CABG) surgery was 2.3% (in patients with an average age of 60.5 years). By 2016, the mortality rate for CABG had more than halved to 1.04% despite the population getting older (average age of 66.1 years). For patients undergoing coronary surgery electively, the most recent mortality rate is only 0.56%.

A similar trend is seen in aortic valve replacement surgery (the second most common procedure in cardiac surgery). In 1993, the mortality rate for isolated aortic valve replacement was over 4% but by 2016, it had fallen to 1.67%. There have been other, more subtle changes in the types of procedures being performed. In the early 1990s, a third of patients who underwent CABG had only one or two bypass grafts performed. With the introduction of angioplasty and stenting, it is now rare to perform CABG for anything other than triple-vessel disease.

The last in the series of hardback Blue Books in collaboration with Dendrite was the sixth edition, published in 2008 by Ben Bridgewater and Bruce Keogh. A subsequent online Blue Book, primarily aimed at the public rather than the profession, was published in 2011. The aim of the new version published here was to review longer-term trends on a national level. The findings of this current retrospective 15-year Blue Book review confirm that over the decades, surgical outcomes have improved in all aspects of adult cardiac surgery. This is on a background of patients getting older, with more coexisting medical conditions and needing more complex surgical procedures. Nevertheless, as *Chapter 8: The effect of outcomes reporting on cardiac surgery* explains, this continual progress in outcomes analysis and publication has brought along unforeseen challenges.

1.4 Future challenges

With mortality rates decreasing to such a low level and increasing variability in patient populations and procedures, the ability of the previous analytical process to identify outliers in surgical performance may be diminished. There is a risk of identifying any surgeon/unit as an outlier purely by chance alone. Equally, when mortality is so low nationally, making analyses that provide meaningful results becomes more difficult. Morbidity, rather than mortality, may be a better indicator of the quality of care and the most recent NACSA report in 2019 has concentrated on morbidity for CABG patients.[6] The current challenge is to develop systems of data collection and analysis that provide the public with confidence that cardiac surgery is safe in the UK with outputs that are understandable by the public as well as being relevant for surgeons and other healthcare providers.

Increasingly, healthcare is provided by teams, systems and pathways of care. Historically, consultants had acted independently from each other and other healthcare professionals, and assumed sole responsibility for their patients' outcomes, but today patients have shared care involving multidisciplinary teams. This has led to a professional debate around whether individual surgeons should continue to be held solely responsible in public reports for the overall outcomes of patients. This argument is rehearsed further in *Chapter 8: The effect of outcomes reporting on cardiac surgery*.

Finally, the growth of digital technology and the need for robust data governance has brought along the additional challenge of maintaining patient confidentiality. The General Data Protection Regulation (GDPR) laws have brought in hurdles that make the use of 'big data' in healthcare more cumbersome. One of the benefits of having multiple large datasets, which can track individual patients, is the potential to link the datasets and look at long-term outcomes of multiple treatments.

While large national organisations may be able to fund the necessary measures to comply with GDPR, individual professional bodies such as the SCTS are not likely to be able to do so. Even for this Blue Book, we were unable to link the outcomes data presented here with data from the ONS to track longer-term survival. It is important, however, that access to these datasets continues to made available to the professional societies and research teams (many of which may be small and relatively poorly funded) so that improvements to care can continue to be audited, researched and delivered. After all, it is these surgeons and teams that we rely on for the collection and input of high quality data.

References

1. English TA, Bailey AR, Dark JF, Williams WG. The UK cardiac surgical register, 1977–82. *Br Med J (Clin Res Ed)* 1984; **289**: 1205–1208
2. Kennedy I. *The Report of the Public Inquiry into Children's Heart Surgery at the Bristol Royal Infirmary 1984–1995: Learning from Bristol*. Norwich: TSO; 2001
3. The Guardian. Heart surgery data: risk adjusted. https://www.theguardian.com/society/2005/mar/16/NHS (cited October 2020)
4. *2019 NCAP Annual Report*. London: NICOR; 2019
5. Society for Cardiothoracic Surgery. Hospitals. https://scts.org/hospitals/ (cited October 2020)
6. *National Adult Cardiac Surgery Audit: 2019 Summary Report (2015/16–2017/18 Data)*. London: NICOR; 2019

Chapter 2: Coronary artery bypass surgery

Umberto Benedetto and Sunil Ohri

2.1 Introduction

This summary report analysed data over the period 2002–2016 from 347,626 patient records: 282,385 patients with isolated coronary artery bypass graft (CABG) surgery, 61,109 with combined CABG and valve procedures, and 4,132 with 'redo' CABG procedures. The primary objective was to generate an update on the status of CABG in the UK and Ireland, and identify trends over the years. The secondary objective was to analyse data reporting, quality and outcomes for CABG. In addition, this evaluation may forecast future trends, and frame recommendations for changes to database management and performance indicators for data reporting and outcome measures. This is important as healthcare planning, quality improvement and policy decisions need to be dynamic and reflect changes in activity and need.

2.2 Results

2.2.1 Reporting volumes

An overview of the overall numbers for isolated CABG, CABG and valve, and redo CABG procedures over the period 2002–2016 is given in Figure 1. There has been an 18% expansion in the cardiac surgical consultant workforce contributing to the database and a further 13% increase in the number of reporting units (Figure 2). The mean number of (all) CABG procedures reported per cardiac unit has, however, decreased from 720 procedures per year to 449 per year (37.6% reduction). Similarly, the average CABG volume reported per surgeon has decreased from 124 to 74

Figure 1

Distribution of different types of CABG procedures performed, 2002–2016

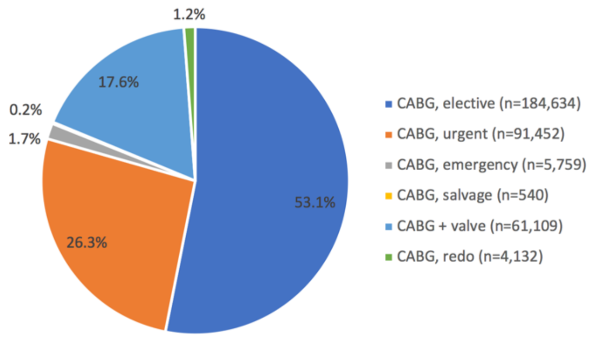


Figure 2

Numbers of hospitals and surgeons performing CABG procedures

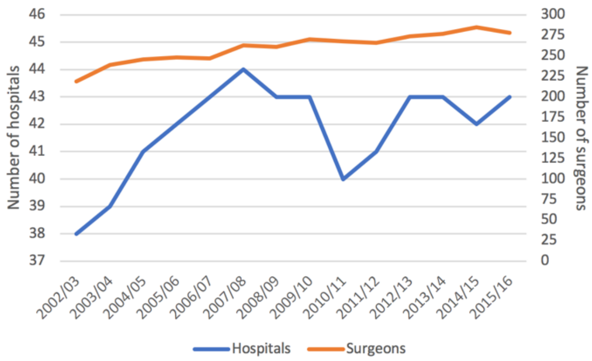
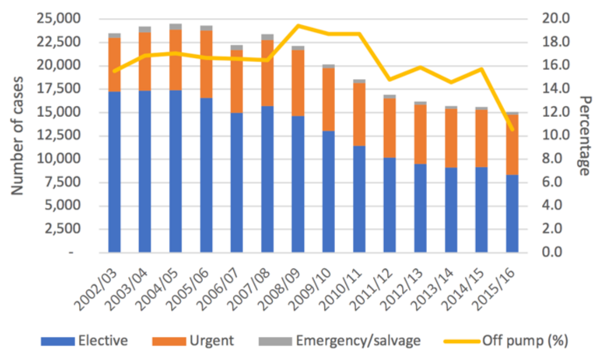


Figure 3

Case volumes for isolated CABG by operative urgency and proportion of all isolated CABG performed off pump



procedures per year (40.3% reduction) over this period.

2.2.2 Isolated CABG

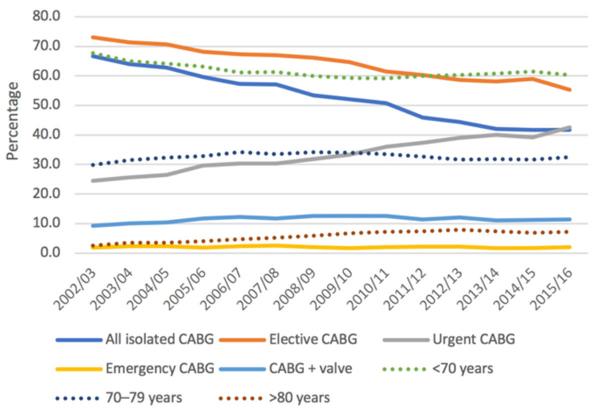
Case volume trends

Case volumes for isolated CABG have decreased steadily, with a 36.1% decrease in reported volumes overall. Approximately 90% of the cases were performed on pump in 2015–2016. This compared with almost 80% in 2008–2010 (Figure 3).

As a proportion of overall cardiac surgical activity, isolated CABG has steadily and consistently declined over the years, from 66.6% in 2002–2003 to 41.7% in 2015–2016 (Figure 4). Over the period studied, there has been a 51.6% reduction in elective isolated CABG activity. Urgent isolated CABG activity has increased by 11.4%, which has only partially compensated for the reduction in elective activity. Urgent CABG now represents 42.6% of all isolated CABG activity. There were no significant changes in emergency (~2% of isolated CABG) or salvage (~0.2% of isolated CABG) cases. The proportional caseload remained similar for patients aged <80 years whereas for those aged >80 years, it increased.

Figure 4

Proportional caseloads for different CABG procedure groups and different age groups. Percentages for 'all isolated CABG' and 'CABG + valve' cases are with reference to overall cardiac activity.



PCI vs isolated CABG

British Cardiovascular Intervention Society data show that the number of percutaneous coronary interventions (PCIs) performed each year has more than doubled, from 44,913 in 2002 to 100,483 in 2016 (Figure 5). The PCI rates over this period increased from 759 to 1,530 per million population. The number of PCI centres increased from 64 to 119. In 2016, 6.7 PCIs were performed for each isolated CABG procedure (Figure 6). This compared with only 1.1 PCIs per isolated CABG procedure in 1999, when the number of PCIs performed first overtook the number of CABG cases.

Figure 5

Numbers of PCI and isolated CABG procedures performed each year

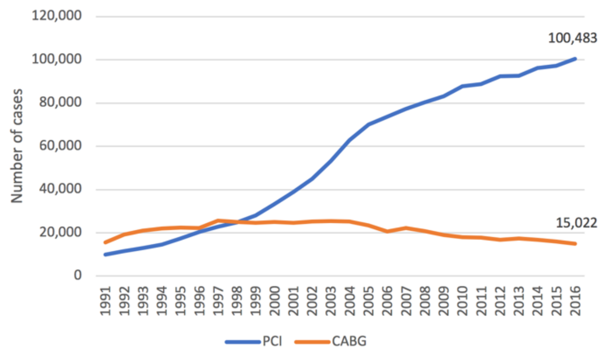
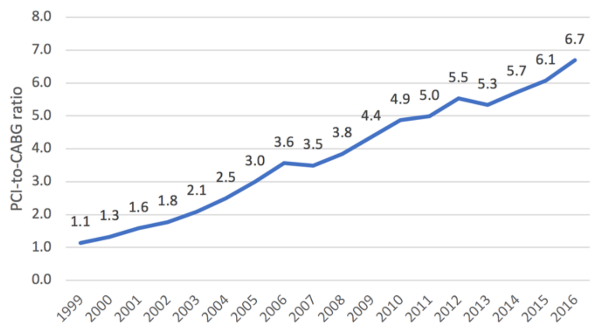


Figure 6

Ratios of PCI to isolated CABG procedures



2.2.3 Patient-level trends

Mean age

The mean patient age for isolated CABG procedures for the period 2002–2016 was 65.7 years. There has been a very slow but steady increase over the years (Figure 7).

Surgical risk profile

The mean logistic EuroSCORE (European System for Cardiac Operative Risk Evaluation) for all isolated CABG was 4.6. For elective and urgent CABG surgery, it remained similar over the period reviewed, with an overall mean of 3.1 and 5.9 respectively. The mean logistic EuroSCORE for emergency and salvage cases was 23.2 and 35.7 respectively. The proportion of patients in a critical preoperative state (defined as cardiorespiratory instability requiring balloon pump, inotropic or vasopressor support, or ventilation) was around 5% while 6% had poor left ventricular function (ejection fraction <30%) at presentation (Figure 8). Around 2% of patients presented with unstable angina and the incidence of ischaemic septal defects was <0.2%. These figures remained largely unchanged over the years but there was an increase in those who had suffered myocardial infarction, from 13.6% in 2002–2003 to 17.8% in 2015–2016.

2.2.4 Outcomes and quality

Arterial grafting

Use of the left internal thoracic artery remained high at >90% in the latter years compared with around 80% in 2002–2003 (Figure 9). The mean number of grafts used was 3 and this did not change significantly. Use of more than one arterial graft, however, declined from 18.3% to 10.2%. Off-pump CABG also declined, from 15.6% to 10.6%. It peaked in 2008–2009, when a fifth of all CABG procedures were performed off pump. These data compare favourably with other data from Europe, North America and Oceania, which also reported use of at least one arterial graft in over 90% of patients.[1–3]

Figure 7

Mean patient age for CABG procedures

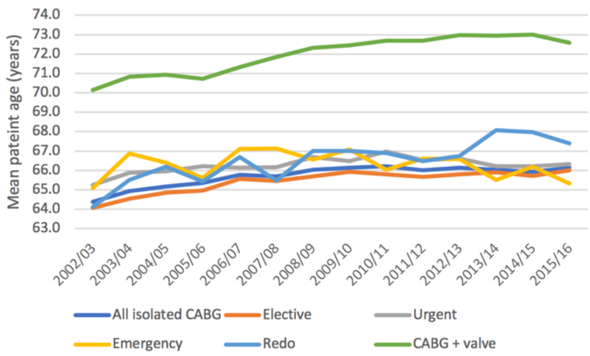


Figure 8

Clinical presentation at admission

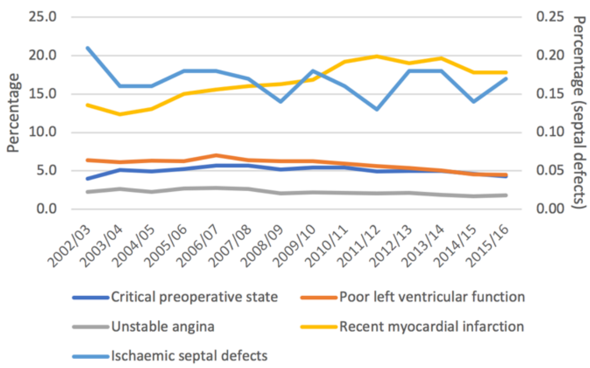
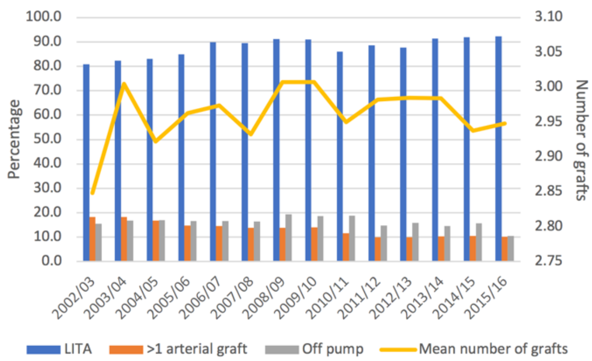


Figure 9

Use of bypass grafts



Expected vs observed mortality

There was a general improvement in in-hospital mortality across all groups (Figures 10 and 11). Expected mortality rates were calculated from the logistic EuroSCORE. Observed in-hospital mortality was consistently less than half of expected mortality and there was a significant improvement for all operative procedures over the years reviewed (Table 1).

Length of hospital stay

The mean for the annual median lengths of stay for isolated CABG patients overall was 6 days (elective: 6 days, urgent: 7 days, emergency: 8 days). This did not change significantly over the period reviewed. For octogenarians, the mean was 9 days compared with 7 days for patients aged 70–79 years and 6 days for those aged <70 years.

2.2.5 Specific subgroups

Combined CABG and valve procedures

The mean age for patients undergoing combined CABG and valve procedures was 72.0 years, which was just over 5 years older than for isolated CABG. The proportional number of cases remained

Figure 10

Expected and observed in-hospital mortality rates for different CABG procedures

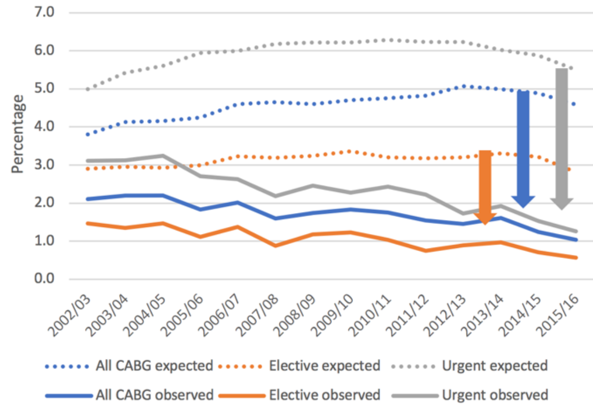


Figure 11

Expected and observed in-hospital mortality rates for isolated CABG procedures by age group

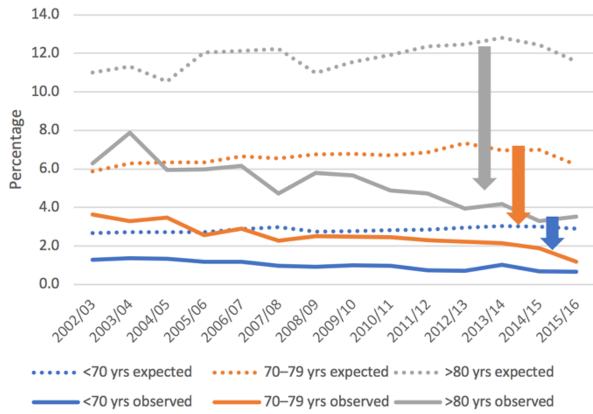


Table 1

Improvement in in-hospital mortality rates for CABG procedures

	2002–2003			2015–2016		
	Expected mortality	**Observed mortality**	**Reduction**	**Expected mortality**	**Observed mortality**	**Reduction**
Isolated CABG						
Elective	2.9%	1.5%	48.3%	2.8%	0.6%	78.6%
Urgent	5.0%	3.1%	38.0%	5.5%	1.3%	76.4%
Emergency	18.7%	11.7%	37.4%	26.0%	6.6%	74.6%
Overall	3.8%	2.1%	44.8%	4.6%	1.0%	78.3%
CABG + valve	9.9%	7.9%	20.2%	10.6%	4.0%	62.3%
Redo CABG	9.1%	7.1%	22.0%	12.6%	7.7%	38.9%

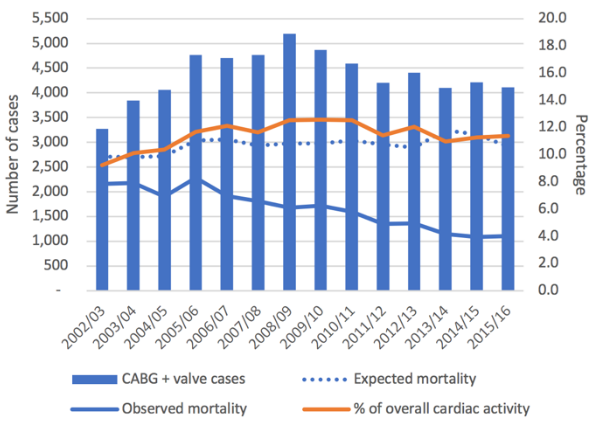
fairly constant at 10–12% of overall activity for units (Figure 12), unlike for isolated CABG. The mean logistic EuroSCORE (10.3) was almost double that for isolated CABG. The median length of stay was significantly more than for isolated procedures at an overall mean of 9 days.

Octogenarian patients

The mean age for octogenarian patients undergoing isolated CABG surgery was 82.2 years. Their proportional case numbers increased almost threefold to 7.1% by 2015–2016. The mean logistic EuroSCORE was 11.8 and the risk profile generally remained unchanged. The observed mortality rate decreased by almost 50%, from 6.3% in 2002–2003 to 3.5% in 2015–2016 (Figure 13). However, this is still 3–5 times higher than the observed mortality for other age groups.

Figure 12

Case volumes and in-hospital mortality rates for combined CABG and valve procedures



CABG in emergency and salvage cases

Although the proportional numbers for emergency and salvage cases have remained the same (around 2% and 0.2% respectively), the total numbers for emergency CABG decreased by a third between 2002–2003 and 2015–2016, consistent with the declining numbers for isolated CABG. The expected and observed mortality rates for salvage cases remained high but observed mortality significantly improved for emergency cases (from 11.7% in 2002–2003 to 6.6% in 2015–2016) despite a higher predicted mortality rate (18.7% vs 26.0%) (Figure 14).

Redo CABG

There has been a continued reduction in redo CABG surgery, commensurate with the growth in PCI experience and improvement in interventional experience

Figure 13

Case volumes and in-hospital mortality rates for isolated CABG patients aged >80 years

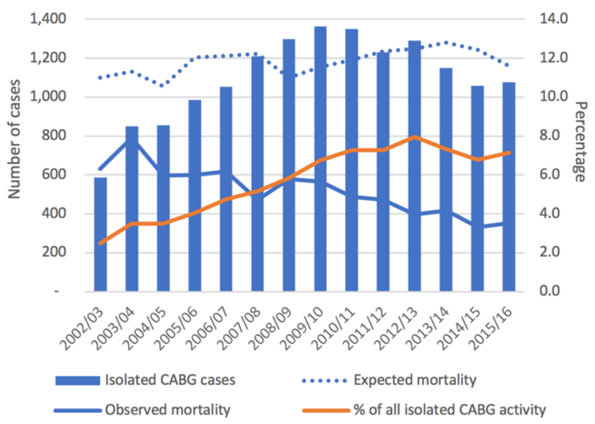
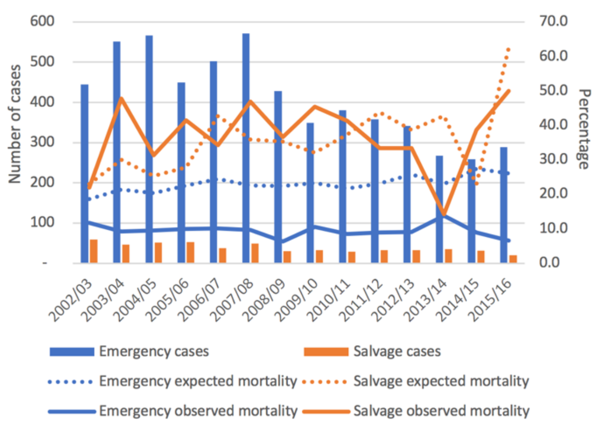


Figure 14

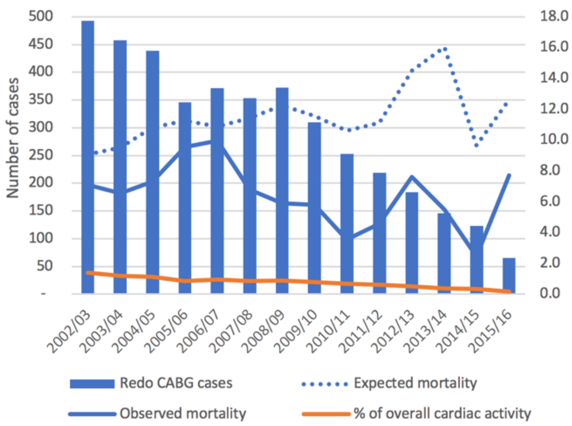
Case volumes and in-hospital mortality rates for emergency/salvage CABG procedures



and technology. Only 65 redo CABG operations were performed in 2015–2016 (0.2% of overall activity) compared with almost 500 cases in 2002–2003 (Figure 15). The surgical risk profile of this referral group has increased substantially (logistic EuroSCORE 9.1 in 2002–2003 but 12.6 in 2015–2016). These cases are probably being increasingly referred for PCI as a less invasive option, particularly if a patent left internal thoracic artery is present. The observed mortality rate was 6.5% (almost 7 times the current mortality rate for isolated CABG), which was still half of the expected mortality rate in this group.

Figure 15

Case volumes and in-hospital mortality rates for redo CABG procedures



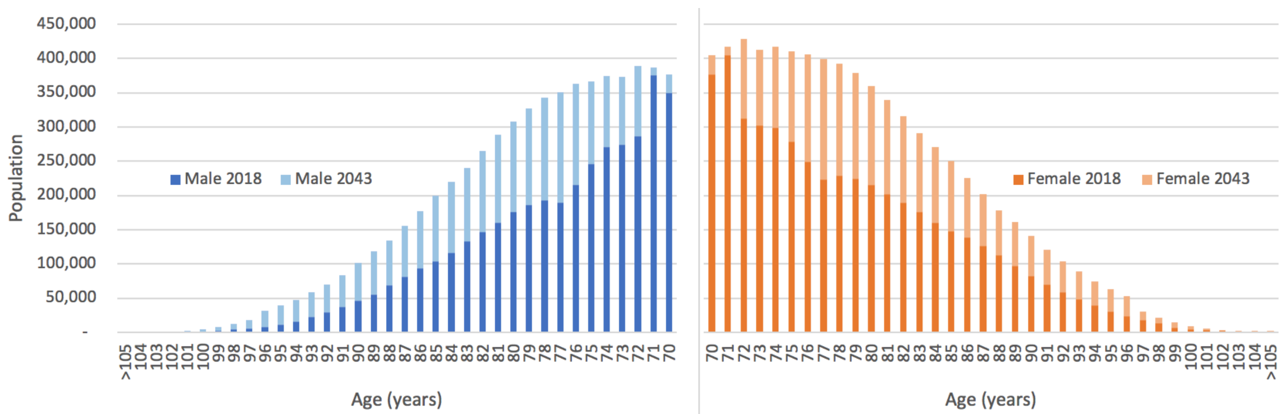
2.3 Future projections

These trends support the view that the number of isolated CABG cases may continue to decline owing to advances in PCI, improving stent patency rates, and broader indications for PCI use in left main stem and triple-vessel disease. At the same time, PCI volumes, which have increased at a rate of 15–20% each year over the last 15 years, could continue to increase and the proportional demographics will be skewed towards an aging population (Figure 16).

According to the Office for National Statistics, the population has grown by 9.6% over the period of this review with an annual growth of almost 0.7% per year during the last decade.[4] For the next decade, there is a projected growth of up to 23% for octogenarians. Based on assumed linear trends from the last few years, the percentage activity for octogenarians in a typical cardiac unit is likely to rise from the present 7.2% to almost 12% over the next 15 years (Figure 17). Furthermore, life expectancy at age 65 years (the mean age for isolated CABG patients) is currently 18.6 years for men and 21.0 years for women.[5] This will present challenges in both the potential provision and the cost of care. For older patients, length of stay is likely to

Figure 16

Projection for population growth for age group over 70 years in the UK (Office for National Statistics data)



increase, and postoperative recuperation will need reinforcement of referral and peripheral non-surgical rehabilitation centres as well as social care.

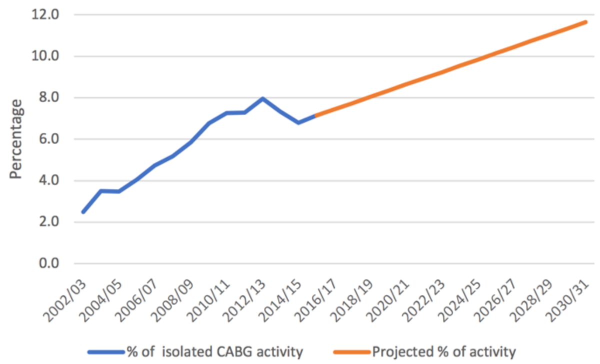
The volume of combined CABG and valve cases has remained steady over the last decade, and this trend might continue in the future. There is a possibility, however, that with rapid expansion of transcatheter valve implantation services, the proportion of older patients will decrease in this subgroup. Similarly, redo CABG cases will continue to decline as most patients are now referred for PCI. There is likely to be an ever decreasing pool of surgeons who have experience of performing redo CABG.

The mortality rates across all groups are some of the lowest in the world despite increasing age, risk profile and frailty of patients, and decreasing experience of the consultant workforce. Further improvements in mortality will probably be very difficult to achieve. Efforts would need to be directed to further reducing morbidity and length of stay, and increasing efficiencies elsewhere.

Although the direct impact on outcomes of comorbidities such as diabetes, hypertension, smoking and obesity has not been analysed here, other national databases have reported increasing comorbidities in population groups.

Figure 17

Projection for CABG activity in patients aged >80 years



Emphasis on preventive strategies can possibly further reduce length of stay and morbidity of CABG to increase efficiencies and reduce associated healthcare costs.

Quality outcome measures captured in the database need to include postoperative parameters like blood volume usage, length of ventilation, length of stay on the intensive care unit, readmission to the intensive care unit, readmission after hospital discharge, use of antiplatelet agents on day 1 after CABG surgery, antiplatelet drug therapy at discharge and statins at discharge. The surgical and intensive care databases remain separate in UK units, and these need to be merged to capture and report these data points. Historically, morbidity and complications were not as well recorded in the database, and completeness was not good enough over this period to draw valid conclusions. This has recently improved, and the 2019 National Cardiac Audit Programme report specifically includes data on morbidity and waiting times for CABG surgery.[6]

These national results for CABG surgery are among the best in the world, comparing favourably with findings from Europe, North America and Oceania.[1–3,7] Other databases have reported similar trends in increasing age and risk profile of patients, decreasing case volumes at the expense of PCI and overall improving mortality.

The Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database (with data from all 50 US states, 10 sites in Canada and 21 participants in 7 other countries) reported an operative mortality rate of 2.2% and a mean length of stay of 6.9 days for 156,931 isolated CABG cases in 2016.[2] CABG patients were increasingly more likely to be diabetic (49% in 2016) and of non-elective status (63% in 2016), and to have undergone a prior PCI (31% in 2016). The frequency of any degree of congestive heart failure increased by approximately 7% during the last decade. Off-pump CABG was used in only 13% of procedures.

The SWEDEHEART (Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies) 2016 report from the Swedish Cardiac Surgery Registry also noted a decreasing trend in overall case numbers with the lowest annual volume of cases for the period 1992–2016 recorded in 2016 (40% reduction in overall case volumes).[7] PCI accounted for 70–90% of all coronary interventions after exclusion of diagnostic PCI and ST-elevation myocardial infarction cases. These changes were despite the recommendations and guidelines for surgical revascularisation by the European Society of Cardiology/European Association for Cardio-Thoracic Surgery[8] and the American College of Cardiology/STS.[9] SWEDEHEART showed an almost fivefold increase in the octogenarian population over the period 1992–2016.[7] The operative mortality rate was 1.6% with a mean length of stay of 7 days. The German Society for Thoracic and Cardiovascular Surgery has demonstrated similar trends in increasing age and decreasing overall case volumes.[1]

At present, outcomes are measured based on objective standard clinical metrics. Patients receiving care may not directly relate to these. Care pathways need to address this lacuna for quality reporting by addition of ‘patient-reported outcomes’ at various time intervals in the care pathway.[10] The Care Quality Commission, the independent regulator of health and social care in England, monitors institutions for safety, effectiveness and care in addition to responsiveness and leadership to maintain the highest levels of service delivery.[11] Patient feedback and ‘friends and family’ tests have been used extensively to directly gauge the quality of patient care in the NHS. These direct patient-reported outcome measures need to be developed specifically for CABG surgery.

2.4 Conclusions

Quality of care and outcomes for patients treated by CABG surgery, as measured by mortality, have improved consistently over the last 15 years despite increasing patient risk profiles. There is a growing trend towards inpatient urgent referrals for surgical revascularisation as seen by decreasing elective caseloads and increasing urgent cases. The demographics of patients, the profile of service delivery and training needs are likely to change substantially over the next 15 years. These would present increasing challenges for the cost and delivery of care to increasingly older patients.

References

1. Beckmann A, Meyer R, Lewandowski J *et al*. German Heart Surgery Report 2018: the annual updated registry of the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2019; **67**: 331–344
2. D’Agostino RS, Jacobs JP, Badhwar V *et al*. The Society of Thoracic Surgeons Adult Cardiac Surgery Database: 2018 update on outcomes and quality. *Ann Thorac Surg* 2018; **105**: 15–23
3. ANZSCTS Cardiac Surgery Database Program. *National Annual Report 2018*. Melbourne: Monash University; 2019
4. Kingston A, Comas-Herrera A, Jagger C. Forecasting the care needs of the older population in England over the next 20 years: estimates from the Population Ageing and Care Simulation

(PACSim) modelling study. *Lancet Public Health* 2018; **3**: e447–e455

5. Office for National Statistics. *National Life Tables, UK: 2016 to 2018*. Newport: ONS; 2019
6. *2019 NCAP Annual Report*. London: NICOR; 2019
7. *SWEDEHEART Annual Report 2016*. Stockholm: Karolinska Institute; 2017
8. Windecker S, Kolh P, Alfonso F *et al*. 2014 ESC/EACTS Guidelines on myocardial revascularization. *Eur Heart J* 2014; **35**: 2541–2619
9. Patel MR, Dehmer GJ, Hirshfeld JW *et al*. ACCF/SCAI/STS/AATS/AHA/ASNC/HFSA/SCCT 2012 Appropriate use criteria for coronary revascularization focused update. *J Am Coll Cardiol* 2012; **59**: 857–881
10. HealthMeasures. PROMIS. https://www.healthmeasures.net/explore-measurement-systems/promis/ (cited October 2020)
11. Care Quality Commission. Key lines of enquiry for healthcare services. https://www.cqc.org.uk/guidance-providers/healthcare/key-lines-enquiry-healthcare-services (cited October 2020)

Chapter 3: Aortic valve surgery

Max Baghai and Olaf Wendler

3.1 Introduction

The number of patients affected by aortic valve disease, in particular aortic stenosis (AS), is constantly rising owing to demographic changes. The incidence of severe AS is around 4% in octogenarians and this trend will therefore continue for some time.[1] Aortic valve therapy has seen dramatic changes over the last ten years with the introduction of new surgical and interventional treatment opportunities. On the surgical side, the introduction of limited access surgery, valve-sparing surgery and clinical trials of new bioprostheses have been the most important developments. Limited access aortic valve/root surgery, mainly performed through upper limited sternotomies, reduces postoperative pain and improves mobilisation. Valve-sparing techniques, only recommended in patients with aortic regurgitation, offer the opportunity to eliminate the risk of early bioprosthetic degeneration in younger patients as well as the avoidance of lifelong anticoagulation.

Sutureless bioprostheses facilitate valve implantation through minimally invasive access, with shorter cardiac ischaemic times reported. However, while prosthesis–patient mismatch seems to occur less often, additional risks of paravalvular leakage and arterioventricular blockage with the need for pacemaker implantation have been reported. Other new developments of bioprostheses focus on prolonged durability, which has contributed to a constant rise in the use of biological valves in patients undergoing aortic valve replacement (AVR). This trend has also been supported by the fact that when using valve-in-valve transcatheter aortic valve implantation (TAVI), repeat AVR through open heart surgery can be avoided.

TAVI offers an interventional technique to reduce the operational trauma of aortic valve therapy for AS. Since its introduction in the UK in 2007, various TAVI devices have received CE mark approval for the treatment of high- and intermediate-risk older patients during the observation period of this report.[2] Initially, treatment focused on native AS but nowadays, valve-in-valve TAVI is also a guideline-supported approach to treat non-infectious bioprosthetic degeneration. The introduction of these technologies has further increased the patient pool considered appropriate for invasive aortic valve therapy. Moreover, it has raised awareness of aortic valve disease among physicians and as a result, the overall number of patients treated for AS is constantly rising.

3.2 Results

3.2.1 Total AVR activity

The total number of AVRs performed per year has generally increased, to a maximum of 12,483 in 2014–2015 (Table 2). This accounts for over 33% of the overall cardiac surgical activity, which is a rise from 20% in 2002–2003. This can most likely be explained by the ageing population, in whom AS is found more frequently. Nevertheless, it is important to note that the mean age of patients who underwent AVR only increased from 66 years in 2002–2003 to 69 years in 2015–2016. Consequently, only a small proportion of these additional older patients who present with AS have undergone AVR surgery.

The older population has benefited from the availability of TAVI since 2007. After exponential growth over the last 12 years, the annual activity reached 3,250 procedures in 2015–2016 (Figure 18), reflecting the promising outcomes from two randomised trials on high-risk and intermediate-risk patients during this time period.

The median age of the TAVI population in the UK and Ireland remains unchanged at around 83 years. The logistic EuroSCORE (EuroSCORE (European System for Cardiac Operative Risk Evaluation) has decreased over time to 18 in 2015–2016 and a large proportion of TAVI patients have undergone previous open cardiac surgery, reflecting that until 2015–2016, mainly high-risk older patients were treated in the UK. The very promising outcomes with an in-hospital mortality rate of 1.8% in 2016 and the recent outcomes from randomised trials on low-risk older patients with AS will in the future probably result in further growth of TAVI activity. This could potentially affect surgical volumes of patients with AS but the current data do not show major effects of this yet.[2,3]

It is important to note that in the UK in 2017, TAVI procedures were only performed in up to 50 patients per million population. This is in contrast to other European countries, such as Italy (50–100 per million), France (100–150 per million) and Germany (>150 per million), where TAVI was introduced at the same time.[4] With the limited data available, it is difficult to say whether this is explained by a more evidence-based TAVI enrolment in the UK according to European guidelines[5] or by the variation of medical financial resources between European countries.

Table 2

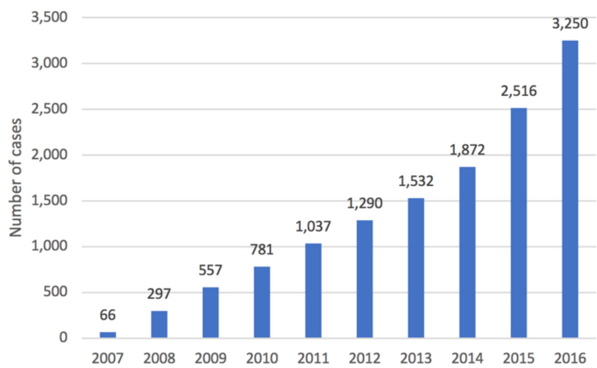
Total number of AVR procedures performed per year

Column	Value
1	Year
2	Total number of AVRs
3	Mean age (years)
4	Mean logistic EuroSCORE
5	Median postoperative length of stay (days)
6	In-hospital mortality rate
7	% of overall cardiac activity

1	2	3	4	5	6	7
2002/03	7,009	65.8	8.7	8	5.6%	19.8%
2003/04	8,145	66.8	9.2	8	5.8%	21.4%
2004/05	8,661	67.3	9.4	9	5.6%	22.2%
2005/06	10,132	67.4	9.6	9	5.0%	24.8%
2006/07	9,969	67.8	10.2	8	5.2%	25.7%
2007/08	10,629	68.0	10.2	8	4.9%	25.9%
2008/09	11,800	68.5	10.4	8	4.9%	28.5%
2009/10	11,343	68.7	10.1	8	4.4%	29.3%
2010/11	11,061	69.0	10.5	8	4.6%	30.2%
2011/12	11,484	69.2	10.5	8	3.9%	31.2%
2012/13	11,857	69.1	11.0	8	3.9%	32.5%
2013/14	11,973	69.1	11.5	8	3.5%	32.1%
2014/15	12,483	69.3	11.5	8	3.4%	33.4%
2015/16	12,322	68.9	10.1	8	3.4%	34.1%
Overall mean	**10,633**	**68.2**	**10.2**	**8**	**4.6%**	**27.9%**

Figure 18

Number of TAVI procedures performed per year, 2007–2016



Isolated AVR

The number of isolated AVRs has grown steadily, with 4,919 operations performed in 2015–2016 (Table 3). The mean age in these patients has increased from 64 years in 2002–2003 to 69 years in 2015–2016. The mean logistic EuroSCORE increased until 2014–2015 (maximum 9.7) and since then, it decreased to 7.9 in 2015–2016; both of these changes could be interpreted as a result of the introduction of TAVI in larger numbers of older intermediate-risk patients with AS. Surgical outcomes have greatly improved since 2002–2003, when the in-hospital mortality rate was 3.6%, to 1.7% in 2015–2016. The median postoperative length of stay remained stable at 7–8 days.

AVR combined with CABG

The volume of combined operations increased until 2008–2009, with a maximum of 4,138 (Table 4). Since 2013–2014, the patient numbers for AVR plus coronary artery bypass graft (CABG) surgery have been approximately 3,300 per year. The mean patient age has stayed relatively constant since 2010–2011, at around 73 years. The logistic EuroSCORE rose until 2014–2015, with a maximum of 11.1, but has now decreased to 10.1 in 2015–2016, probably again as a result of the availability of TAVI procedures, which can also be combined with percutaneous coronary intervention. Despite the rise in risk profile, the mortality rate has steadily

Table 3

Number of isolated AVR procedures performed per year

Column	Value
1	Year
2	Number of isolated AVRs
3	Mean age (years)
4	Mean logistic EuroSCORE
5	Median postoperative length of stay (days)
6	In-hospital mortality rate
7	% of overall cardiac activity

1	2	3	4	5	6	7
2002/03	3,777	64.3	7.8	8	3.6%	10.7%
2003/04	4,351	64.6	8.0	8	3.6%	11.4%
2004/05	4,546	65.3	8.4	8	3.7%	11.6%
2005/06	4,971	65.4	8.2	8	3.2%	12.2%
2006/07	4,809	66.0	8.9	8	3.2%	12.4%
2007/08	5,279	65.9	8.9	8	3.0%	12.9%
2008/09	5,815	66.9	9.1	8	3.2%	14.0%
2009/10	5,706	66.9	8.9	8	2.7%	14.8%
2010/11	5,263	67.9	8.9	7	2.6%	14.4%
2011/12	4,865	68.6	8.2	7	2.1%	13.2%
2012/13	4,733	68.7	9.1	8	2.4%	13.0%
2013/14	4,671	68.9	9.4	7	1.7%	12.5%
2014/15	4,767	69.0	9.7	7	1.6%	12.8%
2015/16	4,919	68.6	7.9	7	1.7%	13.6%
Overall mean	**4,891**	**66.9**	**8.7**	**8**	**2.7%**	**12.8%**

Table 4

Number of combined AVR and CABG procedures performed per year

Column	Value
1	Year
2	Number of combined AVR and CABG procedures
3	Mean age (years)
4	Mean logistic EuroSCORE
5	Median postoperative length of stay (days)
6	In-hospital mortality rate
7	% of overall cardiac activity

1	2	3	4	5	6	7
2002/03	2,377	71.0	9.4	9	8.0%	6.7%
2003/04	2,871	71.7	9.5	9	7.2%	7.6%
2004/05	3,032	71.6	9.6	9	6.4%	7.8%
2005/06	3,718	71.3	9.6	10	6.2%	9.1%
2006/07	3,603	72.0	10.5	9	6.0%	9.3%
2007/08	3,727	72.5	10.2	9	6.1%	9.1%
2008/09	4,138	73.0	10.5	9	5.7%	10.0%
2009/10	3,892	73.1	10.4	9	5.6%	10.1%
2010/11	3,684	73.3	10.6	9	5.1%	10.1%
2011/12	3,367	73.4	10.3	9	4.3%	9.2%
2012/13	3,552	73.6	10.2	9	4.5%	9.7%
2013/14	3,287	73.4	11.1	9	3.7%	8.8%
2014/15	3,419	73.7	11.1	9	3.5%	9.2%
2015/16	3,298	73.3	10.1	8	3.8%	9.1%
Overall mean	**3,426**	**72.6**	**10.2**	**9**	**5.4%**	**9.0%**

decreased from 7.95% in 2002–2003 to 3.5% in 2014–2015 and 3.8% in 2015–2016. The median length of stay after surgery has remained around 9 days.

3.2.2 Aortic root replacement using valve-sparing surgery

The number of valve-sparing aortic root procedures (David/Yacoub procedures) has been gradually rising from only 26 in 2002–2003 to a maximum of 133 in 2015–2016 (Table 5). Nevertheless, despite increasing scientific evidence that long-term outcomes after these procedures are excellent, overall activity figures in the UK and Ireland still remain low. This is most likely explained by the challenges observed in the training of junior (but also experienced) cardiac surgeons in this sophisticated surgical technique. The mean age of patients treated has always been around 50 years whereas the mean logistic EuroSCORE has varied widely over the last 15 years, between 7 and 25. The in-hospital mortality rate has decreased from 6.0% in the first five years of the period reviewed to 3.5% in the last five years and is comparable with other national registry outcomes but higher than reported from single centre experience.

Table 5
Number of David/Yacoub procedures performed per year

Column	Value
1	Year
2	Number of David/Yacoub procedures
3	Mean age (years)
4	Mean logistic EuroSCORE
5	Median postoperative length of stay (days)
6	In-hospital mortality rate
7	% of overall aortic activity

1	2	3	4	5	6	7
2002/03	26	52.5	14.1	10	11.5%	4.2%
2003/04	36	44.0	7.4	7	2.8%	5.6%
2004/05	28	47.8	11.5	10	3.6%	4.4%
2005/06	44	46.8	9.0	8	4.6%	6.2%
2006/07	40	56.8	11.4	8	7.5%	4.7%
2007/08	57	46.7	13.8	7	0.0%	6.2%
2008/09	84	51.7	16.0	7	6.0%	7.5%
2009/10	69	46.6	14.4	8	7.3%	6.1%
2010/11	75	48.0	10.1	7	4.0%	6.3%
2011/12	123	50.5	18.7	8	2.4%	12.0%
2012/13	174	56.3	20.5	9	4.6%	14.7%
2013/14	104	50.3	24.6	8	5.8%	9.3%
2014/15	129	46.3	16.6	7	1.6%	9.6%
2015/16	133	51.8	11.9	8	3.0%	10.6%
Overall mean	**80**	**49.7**	**14.3**	**8**	**4.6%**	**7.7%**

3.3 Discussion

3.3.1 Future trends

Given the new evidence around TAVI in low-risk older patients with AS, it is expected that a growing number of these patients will no longer undergo AVR in the future.[4] However, the effects on the annual workload of AVR may be less severe in the UK than in other European and North American countries as the proportion of older patients (particularly those aged >80 years) has been historically smaller in the UK surgical cohort.

The use of transcatheter heart valves in younger patients with a life expectancy of more than ten years should be handled with caution until more data on durability are available. New conventional bioprostheses with longer durability will mean that AVR remains the gold standard in patients aged 55–70 years, who benefit from aortic bioprostheses with proven long-term outcomes. More evidence on low-dose anticoagulation therapy after certain mechanical AVRs may also keep this treatment option attractive for patients below 55 years of age. The growth of valve-sparing aortic root surgery will probably increase now that David/Yacoub procedures have become a class I indication for the treatment of aortic root aneurysms with or without aortic regurgitation in patients with tricuspid aortic valves.[5] The database may have underreported these procedures in the past but specific fields have since been added.

3.3.2 Future aspirations

Unfortunately, the data available for this analysis are limited by the historic dataset. For example, it would have been helpful to have more detailed information on the various age groups of patients, more operative data on different surgical access techniques and devices used, and also more data on the morbidity and one-year mortality observed in patients after AVR treatment. As the proportion of minimal access surgery increases in the UK with the aid of new technology, it will be imperative to monitor both short- and long-term outcomes to maintain the gold standard to which we, as surgeons, are accustomed. New fields to record the surgical access approach have now been incorporated in the dataset but were not available before 2016.

3.4 Conclusions

This analysis of patients who underwent aortic valve surgery in the UK and Ireland demonstrates that despite an increase in patient age and risk over the last 15 years, in-hospital mortality has consistently improved. Valve-sparing aortic root replacement is increasingly performed to treat aortic regurgitation in the context of aortic root dilation and the observed perioperative mortality is acceptable. The number of AVRs does not appear to have been significantly affected by the introduction of TAVI. Nevertheless, there is a trend in the last few years towards a plateau of AVRs and a reduction in age of the surgical cohort. This analysis shows that aortic valve surgery in the UK and Ireland is safe, and that it offers the opportunity to effectively treat patients with isolated aortic valve lesions but also those who benefit from CABG surgery at the same time.

References

1. Durko AP, Osnabrugge RL, Van Mieghem NM *et al*. Annual number of candidates for transcatheter aortic valve implantation per country: current estimates and future projections. *Eur Heart J* 2018; **39**: 2635–2642
2. Ludman PF. UK TAVI registry. *Heart* 2019; **105(Suppl 2)**: s2–s5
3. British Cardiovascular Intervention Society. BCIS audit results. https://www.bcis.org.uk/resources/audit-results (cited October 2020)
4. Pilgrim T, Windecker S. Expansion of transcatheter aortic valve implantation: new indications and socio-economic considerations. *Eur Heart J* 2018; **39**: 2643–2645
5. Baumgartner H, Falk V, Bax JJ *et al*. 2017 ESC/EACTS guidelines for the management of valvular heart disease. *Eur Heart J* 2017; **38**: 2739–2791

Chapter 4: Mitral valve surgery

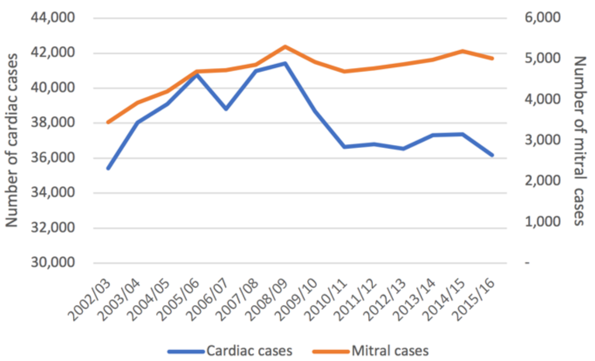
Stuart Grant and Steve Livesey

4.1 Introduction

There have been significant changes in the field of mitral valve surgery over the past two decades. These have occurred as a result of evolving patient demographics, updates to clinical guidelines and advances in operative techniques. An ageing population along with the associated increased prevalence of degenerative and ischaemic mitral valve disease are the key changes in patient demographics. The objective of this report was to provide a comprehensive update on the status of mitral valve procedures in the UK and Ireland, and to identify trends over time. This report includes data collected over the period from 2002 to 2016 inclusive. The data represent all mitral valve operations including those where concomitant procedures such as coronary artery bypass grafting, multiple valve procedures, major aortic procedures or other cardiac procedures were performed.

Figure 19

Overall cardiac surgical activity and overall mitral valve activity



4.2 Results

4.2.1 Mitral valve activity

A total of 65,654 mitral valve procedures were performed during this time period, with mitral procedures representing 12% of total cardiac surgical activity and 31% of overall valve activity. There has been a steady increase in mitral activity despite a plateau in overall cardiac surgical activity (Figure 19). The proportion of cardiac surgery represented by mitral valve procedures has increased from less than 10% in 2002–2003 to around 14% in 2015–2016. This represents an additional 1,500 mitral procedures per year between the first and last years reviewed.

This increase in activity has also been demonstrated in North America.[1] The reasons for the increase in mitral activity are multifactorial but an ageing population along with a trend towards earlier intervention for patients with degenerative mitral disease have both played a significant role.

4.2.2 Operative urgency

The proportion of all mitral valve operations performed electively has remained consistently around 75% over the period reviewed. The proportion of mitral activity performed on an urgent basis has risen by approximately 3% with a fall in the proportion of emergency/salvage cases from around 6% to around 3%. The overall numbers of elective, urgent and emergency/salvage mitral valve operations performed each year are shown in Figure 20. Although data on the aetiology of mitral pathology were not available when compiling this report, it is likely that the fall in emergency mitral valve surgery reflects a decline in the incidence of acute mitral regurgitation secondary to myocardial infarction with the increase in urgent mitral valve procedures probably representing an increase in cases of active endocarditis and ischaemic mitral regurgitation.

Elective mitral valve surgery

Elective procedures make up the vast majority of mitral valve activity in the UK and Ireland (Figure 20). The average age of patients undergoing elective mitral surgery has increased from around 64 years in the earlier years reviewed to around 66 years more recently. This has corresponded with a trend of an increasing mean logistic

Figure 20

Mitral valve activity by operative urgency

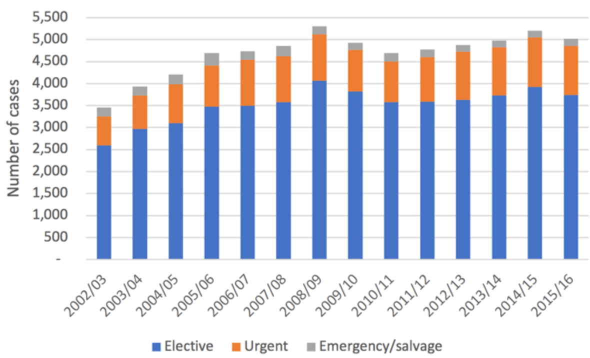
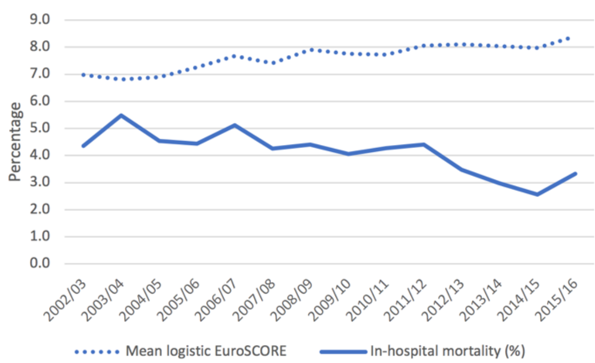


Figure 21

Mean logistic EuroSCORE and in-hospital mortality rates for elective mitral valve surgery



EuroSCORE (European System for Cardiac Operative Risk Evaluation) from 7 to 8 (Figure 21). Despite this trend, in-hospital mortality after elective mitral valve surgery has fallen steadily.

Elective mitral valve repair

There has been a consistent increase in the rate of mitral valve repair in patients undergoing elective surgery, from approximately 40% in 2002–2003 to over 60% in the latter years. The repair and replacement rates for elective mitral valve surgery are shown in Figure 22.

Figure 22

Mitral valve repair and replacement rates for elective surgery

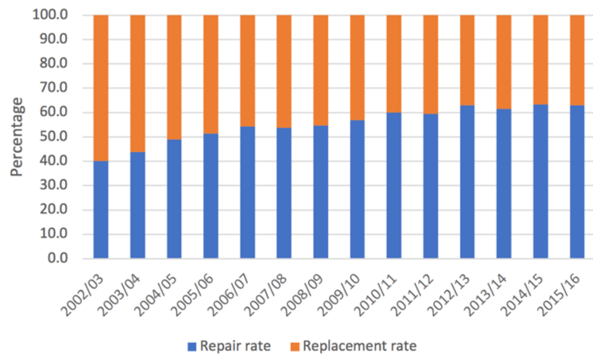
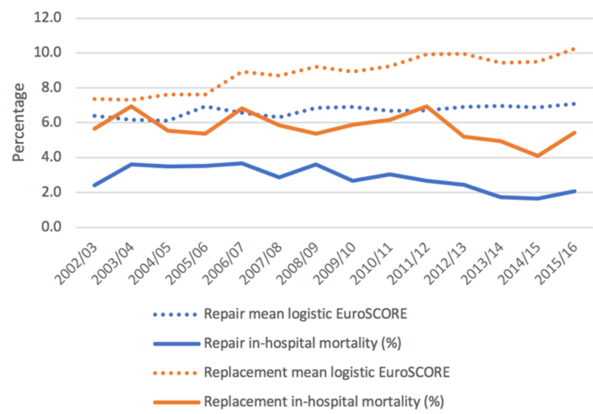


Figure 23

Mean logistic EuroSCORE and in-hospital mortality rates for elective mitral valve repair and replacement



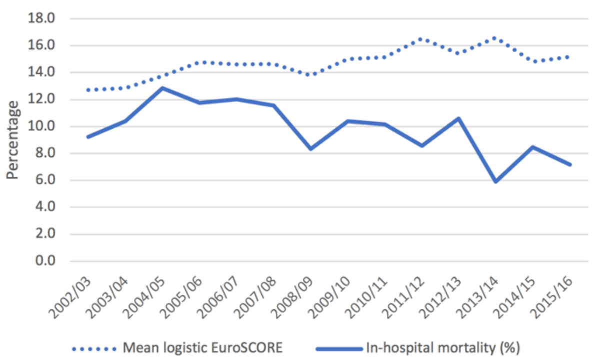
A general trend can be seen towards lower in-hospital mortality for elective mitral valve repair with a mortality rate of under 2% for two of the most recent years (1.8% in 2013–2014 and 1.7% in 2014–2015). This reduction in mortality has occurred despite an increase in mean patient age from 64 to 66 years and a small increase in mean logistic EuroSCORE from approximately 6.4 in 2002–2003 to 7.1 in 2015–2016 (Figure 23). As a result, elective mitral valve repair is an area of cardiac surgery where the overprediction of risk by the logistic EuroSCORE is most apparent. For the most recent years, the overestimation of risk for elective mitral valve repair was more than threefold. This is compensated for by recalibrating the risk model in outcomes analysis for units and surgeons.

Elective mitral valve replacement

The proportion of patients undergoing elective mitral surgery who receive a valve replacement has gradually fallen (Figure 22). Mortality for elective valve replacement has remained consistently higher than for patients undergoing elective mitral valve repair. As with valve repair, the logistic EuroSCORE overpredicts the risk of in-hospital mortality for elective mitral valve replacement, albeit to a lesser extent (Figure 23). Although no data were available for this report on the type of mitral valve replacement, a trend towards increasing implantation of bioprosthetic valves in patients aged over 65 years has been demonstrated previously in an analysis of UK national data.[2]

Figure 24

Mean logistic EuroSCORE and in-hospital mortality rates for urgent mitral valve surgery



Non-elective mitral valve surgery

The proportion of all mitral valve operations performed on a non-elective basis has remained relatively constant at around 25%. During the period reviewed, urgent cases have generally represented over three-quarters of non-elective work and the proportion has increased from 76.1% in the first year to 87.1% in the most recent year. The mean number of urgent mitral operations performed per year is just under 1,000. The average age of patients undergoing urgent mitral surgery is two years younger than for elective surgery but has increased to a similar degree over the time reviewed, from 62 to 64 years. As expected, the mean logistic EuroSCORE for urgent patients is consistently higher than for elective patients and this has increased from approximately 13 in the early years to approximately 15 in the later years (Figure 24). In-hospital mortality for urgent mitral surgery has declined over time.

Each year, an average of 190 emergency or salvage mitral valve operations are performed. The mean age of patients undergoing emergency mitral surgery during the years reviewed is lower than that for both elective and urgent surgery. The mean logistic EuroSCORE and in-hospital mortality rates for emergency/salvage mitral surgery are shown in Figure 25. There has been a trend towards an increase in the mean logistic EuroSCORE, with in-hospital mortality rates between 25% and 30% for the majority of years.

Non-elective mitral valve repair

Compared with elective patients, repair rates for non-elective patients are lower and have remained relatively steady over time (Figure 26). This probably reflects an increased incidence of endocarditis and ischaemic mitral regurgitation in patients undergoing non-elective surgery. There is a trend of declining mitral valve repair rates in non-elective patients in the latter years. This may be partly explained by the results of the Cardiothoracic Surgical Trials Network study comparing mitral valve repair versus replacement in the treatment of severe ischaemic mitral regurgitation, which demonstrated that mitral regurgitation recurred more frequently in the repair group, resulting in more heart failure-related adverse events and cardiovascular admissions.[3]

Repair rates for urgent surgery tend to be around 40–50% with repair rates for emergency surgery generally between 20% and 30%. Interestingly, in 2005–2006, the emergency/salvage mitral repair rate increased to 45.4%, which corresponds with the highest in-hospital mortality observed in emergency/salvage mitral valve patients. The in-hospital mortality rate for urgent mitral valve repair has been consistently lower than for urgent mitral replacement since 2008–2009; over the most recent years, it was under 6%. In-hospital mortality for emergency/salvage mitral valve repair has fluctuated significantly. This is likely to be at least in part because fewer than 60 emergency/salvage mitral valve repairs are performed on average across all the contributing units each year. This patient cohort represents a very heterogeneous group with widely varying degrees of ventricular dysfunction. The in-hospital mortality rates for non-elective mitral valve repair are shown in Figure 27.

Figure 25
Mean logistic EuroSCORE and in-hospital mortality rates for emergency/salvage mitral valve surgery

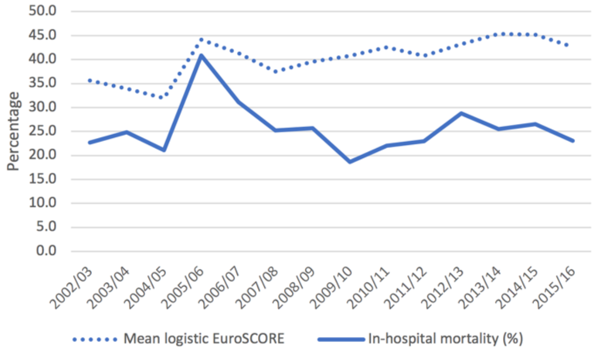


Figure 26
Mitral valve repair rates by operative urgency

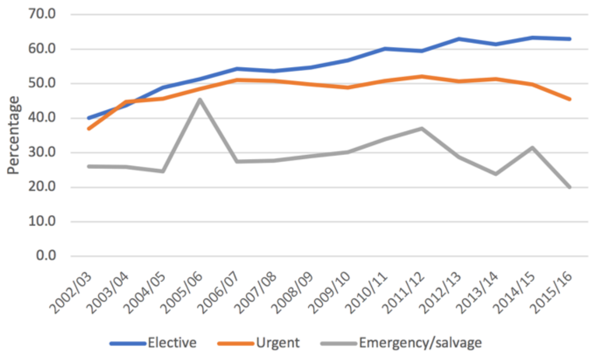
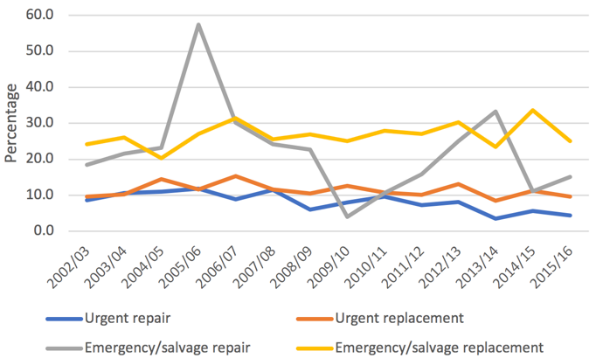


Figure 27
In-hospital mortality rates for non-elective mitral valve repair and replacement



Non-elective mitral valve replacement

Mitral valve replacement is more commonly performed for non-elective patients, with the mean number of urgent and emergency/salvage mitral valve replacements performed each year being 502 and 134 respectively. The in-hospital mortality rates for urgent valve replacement have been consistently between 8% and 15% while the mortality rates for emergency/salvage mitral valve replacement have been in the range of 20–35% (Figure 27).

4.3 Conclusions

There have been significant changes in the field of mitral surgery over the past two decades. The recognition of the natural progression of mitral valve disease and the benefits of earlier intervention have been reflected in updated clinical guidelines.[4] Advances in conventional operative techniques include the wider adoption of minimal access mitral surgery and the emergence of robotic mitral valve surgery. These advances have been accompanied by the development of percutaneous solutions to address mitral valve disease such as the MitraClip™ and transcatheter mitral valve replacement in patients who are not suited to conventional surgery.

This report demonstrates that the overall level of mitral valve activity in the UK and Ireland has increased significantly over the period reviewed. An extra 1,500 mitral valve operations were performed in 2015–2016 compared with 2002–2003. The majority of mitral valve procedures are carried out on an elective basis. Mitral valve repair rates have consistently increased for elective operations to around 60% in the most recent years. The in-hospital mortality rate for elective repair has fallen to around 2%.

Non-elective operations represent approximately 25% of all mitral valve surgery. There has been an increase in urgent mitral procedures and a corresponding decrease in emergency interventions. Mitral valve replacement in non-elective surgery is more common than repair, with roughly 75% of patients undergoing emergency or salvage mitral valve surgery receiving a mitral valve replacement. The in-hospital mortality rate for emergency/salvage mitral valve replacement remains around 25% with significant fluctuation in in-hospital mortality for patients undergoing emergency/salvage valve repair. The in-hospital mortality rate for urgent mitral valve repair has fallen to less than 6%.

Mitral valve surgery will presumably continue to evolve over the next two decades. Percutaneous and transcatheter techniques may have the most significant influence on mitral valve surgery during this time. Early results of transcatheter mitral intervention with the MitraClip™ in patients with heart failure have been mixed.[5,6] There are, however, a significant number of alternative devices, either already developed or under development, that may play a role in the treatment of mitral disease in the future. Owing to the complexity of mitral anatomy and pathology, it is unlikely that the shift to transcatheter intervention will be as rapid as that seen with the aortic valve.

From a surgical perspective, the rate of repair (rather than replacement) for patients with degenerative mitral valve disease will probably increase and minimal access procedures may be performed more frequently. Comparative results have been demonstrated between a minimally invasive approach and conventional sternotomy in a UK multicentre propensity-matched study.[7]

As technology advances and costs come down, it is highly likely that robotically assisted interventions will also become more commonplace. Going forwards, it is important that such anticipated changes in practice are considered by commissioners, regulators and professional societies to ensure that outcomes for patients with mitral valve disease continue to improve.

References

1. Gammie JS, Sheng S, Griffith BP *et al*. Trends in mitral valve surgery in the United States: results from the Society of Thoracic Surgeons Adult Cardiac Surgery Database. *Ann Thorac Surg* 2009; **87**: 1431–1439
2. Dimarakis I, Grant SW, Hickey GL *et al*. Mitral valve prosthesis choice for patients aged 65 years and over in the UK. Are the guidelines being followed and does it matter? *Heart* 2014; **100**: 500–507
3. Goldstein D, Moskowitz AJ, Gelijns AC *et al*. Two-year outcomes of surgical treatment of severe ischemic mitral regurgitation. *N Engl J Med* 2016; **374**: 344–353
4. Baumgartner H, Falk V, Bax JJ *et al*. 2017 ESC/EACTS guidelines for the management of valvular heart disease. *Eur Heart J* 2017; **38**: 2739–2791
5. Obadia JF, Messika-Zeitoun D, Leurent G *et al*. Percutaneous repair or medical treatment for secondary mitral regurgitation. *N Engl J Med* 2018; **379**: 2297–2306
6. Stone GW, Lindenfeld J, Abraham WT *et al*. Transcatheter mitral-valve repair in patients with heart failure. *N Engl J Med* 2018; **379**: 2307–2318
7. Grant SW, Hickey GL, Modi P *et al*. Propensity-matched analysis of minimally invasive approach versus sternotomy for mitral valve surgery. *Heart* 2019; **105**: 783–789

Chapter 5: Major aortic surgery

Deborah Harrington and Graham Cooper

5.1 Introduction

The data in the National Adult Cardiac Surgical Database for major aortic surgery allow us to make some inferences about general trends between 2002–2003 and 2015–2016 but we have not attempted to analyse the data to a greater level of detail. The data for more complex procedures and more detailed levels of operative technique (even after cleaning) were not sufficiently clear to draw firm, reliable conclusions. For this reason, we have not included surgery on the aortic arch as a separate category. Operations involving the abdominal segment of the aorta are not included in the database.

5.2 Results

5.2.1 Total number of aortic procedures

There has been a doubling in the number of major aortic procedures performed, from 615 in 2002–2003 to 1,254 in 2015–2016 (Figure 28). As a proportion of all adult cardiac operations, major aortic procedures represented 1.74% in 2002–2003, rising to 3.47% in 2015–2016. The mean patient age has increased by four years over this time (Figure 29). The mean length of stay, however, remained static.

There has been an increase in mean logistic EuroSCORE (EuroSCORE (European System for Cardiac Operative Risk Evaluation). This is principally seen in the aortic root replacement and ascending aortic surgery cohorts. In-hospital mortality has fallen by around a third, in line with the fall seen in other adult cardiac procedures (Figure 28).

Figure 28
Overall major aortic surgical activity, mean logistic EuroSCORE and in-hospital mortality rates

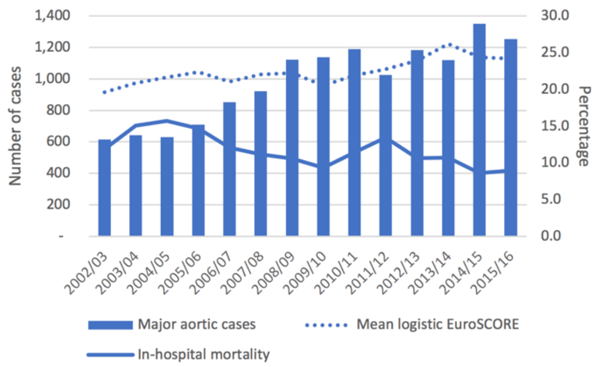
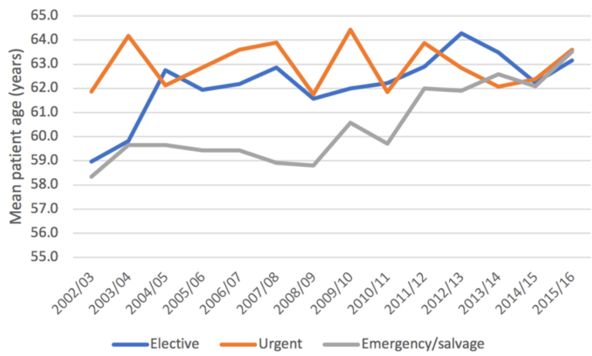


Figure 29
Mean patient age for major aortic surgery



The increase in the number of major aortic procedures performed each year has been similar across those procedures classified as elective, urgent and emergency/salvage (Figures 30–32). The mean logistic EuroSCORE has increased in all three classifications and while mortality has fallen significantly in the elective and urgent cohorts, it has remained relatively static in the emergency group.

Figure 30

Elective aortic surgical activity, mean logistic EuroSCORE and in-hospital mortality rates

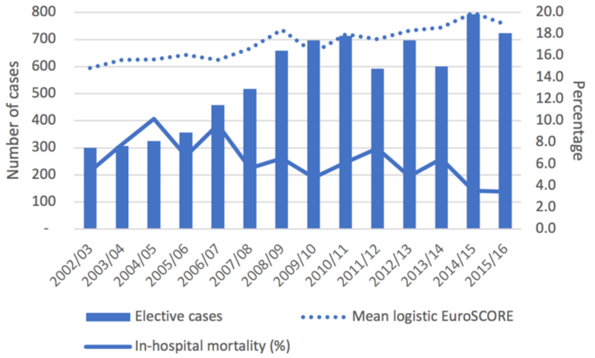


Figure 31

Urgent aortic surgical activity, mean logistic EuroSCORE and in-hospital mortality rates

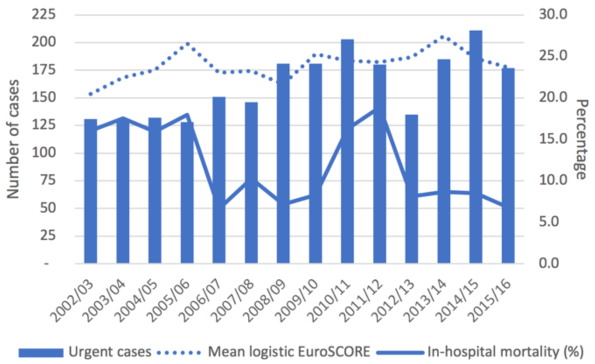
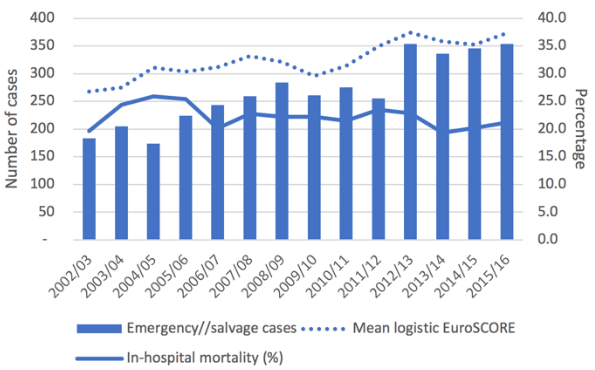


Figure 32

Emergency/salvage aortic surgical activity, mean logistic EuroSCORE and in-hospital mortality rates



5.2.2 Aortic root replacement

The total number of aortic root replacements being performed per year has tripled from 314 procedures in the first year reviewed to 1,034 in the final year (Figure 33). In 2002–2003, valve-sparing procedures constituted 8% of all root replacements while in 2015–2016, this had increased to 13%.

The mean patient age for both types of procedures has remained static, valve-sparing patients being on average five years younger (Figure 34). The mean logistic EuroSCORE has increased, postoperative length of stay has remained similar but in-hospital mortality has decreased in both groups (Figure 35).

Figure 33

Aortic root surgical activity

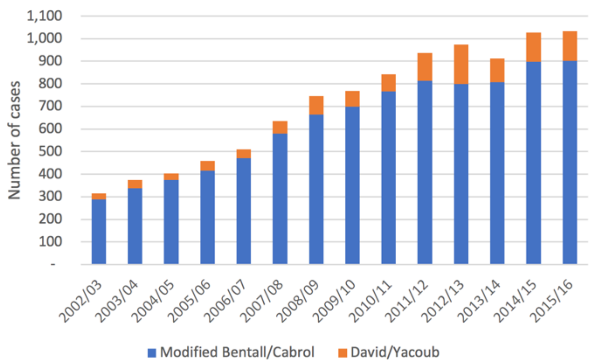
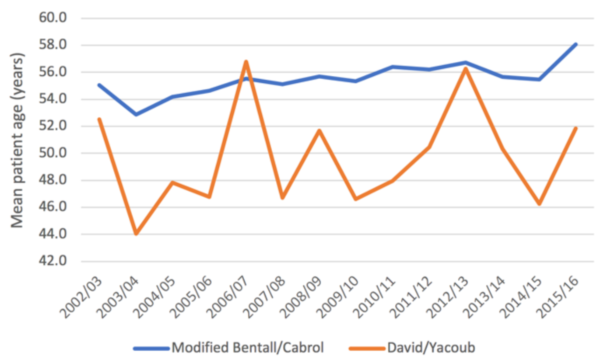


Figure 34

Mean patient age for aortic root surgery



5.2.3 Ascending aorta

Ascending aortic procedures represent the biggest group of major aortic procedures. Their numbers have increased from 545 in 2002–2003 to 1,178 in 2015–2016 (Figure 36). Despite an increase in the mean logistic EuroSCORE (from 19.0 to 23.9), the in-hospital mortality rate has fallen (from 11.6% to 8.9%). There has been little change in patient age and postoperative length of stay.

5.2.4 Descending thoracic aorta

Surgery on the descending thoracic aorta represents the smallest group of major aortic procedures. Surgical activity has fluctuated between 2002 and 2016, with no significant trend (Figure 36). As for the ascending aorta, the in-hospital mortality rate for procedures on the descending aorta fell (from 14.3% to 8.7%) while the mean logistic EuroSCORE increased (from 22.7 to 34.0). Again, there has been little change in patient age and length of stay.

Figure 35
Mean logistic EuroSCORE and in-hospital mortality rates for aortic root surgery

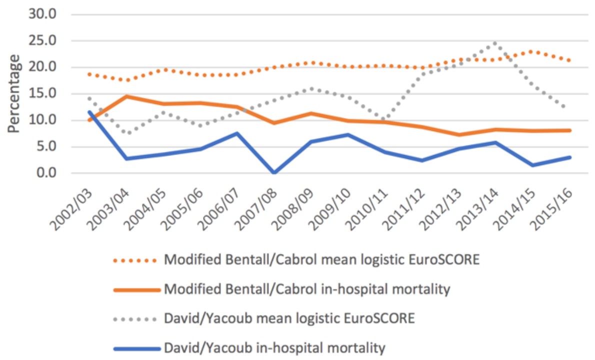
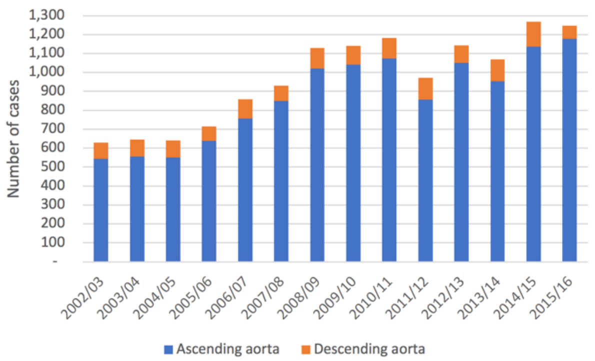


Figure 36
Ascending and descending aortic surgical activity



5.3 Discussion

The doubling of the annual number of major aortic procedures performed over the period reviewed undoubtedly reflects the increase in specialisation in major aortic surgery and developments in surgical technique that have occurred during this time. A greater fall in overall in-hospital mortality may have been expected given the substantial advances in both subspecialisation and the technology. There has been a significant reduction in in-hospital mortality for elective and urgent surgery, by 35% and 58% respectively, but in-hospital mortality for emergency surgery has increased by 8%. This may reflect the fact that elective and urgent surgery is likely to have been carried out by specialist aortic surgeons (especially more recently) while emergencies are still predominantly operated on by non-specialist surgeons. The Liverpool experience shows that when acute type A aortic dissection is operated on by specialist surgeons, mortality halves.[1]

Overall, the logistic EuroSCORE has increased by about 20% but observed in-hospital mortality is now less than half of logistic EuroSCORE prediction. The mean patient age has only increased by 6%, suggesting either that contemporary patients carry greater comorbidity or that recording of comorbidity has improved. Another explanation could be that with the development of specialist aortic surgeons, more complex patients are being offered surgery.

For all cardiac surgery, the mean patient age has increased by two years. In the major aortic procedures cohort, the increase has been by four years. This increase has been seen in all procedures except valve-sparing root replacement and descending thoracic aorta operations.

Over this time period, postoperative length of stay for coronary artery bypass graft and valve operations has fallen by one day. Longer hospitalisation is required for major aortic procedures and this has not shown a convincing reduction.

The increase in the proportion of root replacements that are valve sparing reflects the refinements in techniques and increasing confidence in their durability over this time. Mortality in the valve-sparing group is less than half of that in the modified Bentall group. The valve-sparing procedures will be almost exclusively elective while the Bentall group includes both elective and emergency procedures, predominantly acute type A aortic dissection, explaining the discrepancy in mortality.

Compared with the US and Sweden, the UK and Ireland has low rates of major aortic surgery. Data from the Society of Thoracic Surgeons in the US show 15,000 major aortic operations for the calendar year 2016, representing 5% of all cardiac operations and around 0.0005 operations per 100,000 population. Although this includes operations on the thoracoabdominal aorta, these will be relatively small in number.[2] In Sweden, for the same year, surgeons performed 721 major aortic operations, equating to 13% of all cardiac operations and a rate of 0.007 per 100,000 population.[3] In 2015–2016 in the UK and Ireland, 1,254 major aortic operations represented 3.47% of all adult cardiac surgery at a rate of around 0.0002 per 100,000 population.

The overall 30-day mortality rate in Sweden in 2016 for major aortic operations was 5.8%, compared with 8.9% in the UK. This difference may be explained by the fact that in the UK, the proportion of emergency operations is twice that in Sweden. Emergency cases accounted for 24% of all major aortic operations in Sweden in 2016 whereas here, they represented 42%. This suggests the lower rates of aortic surgery in the UK are, at least partly, explained by an underprovision of elective surgery. It has been demonstrated previously that significant variation exists in the rates of elective surgery across the country.[4]

5.4 Conclusions

The number of major aortic procedures has doubled across the period of this analysis. Despite an increase in logistic EuroSCORE and patient age, in-hospital mortality for elective and urgent surgery has fallen. However, mortality for emergency procedures has not changed.

References

1. Bashir M, Shaw M, Field M *et al*. Repair of type A dissection-benefits of dissection rota. *Ann Cardiothorac Surg* 2016; **5**: 209–215
2. D'Agostino RS, Jacobs JP, Badhwar V *et al*. The Society of Thoracic Surgeons Adult Cardiac Surgery Database: 2018 update on outcomes and quality. *Ann Thorac Surg* 2018; **105**: 15–23
3. *SWEDEHEART Annual Report 2016*. Stockholm: Karolinska Institute; 2017
4. Bottle A, Mariscalco G, Shaw MA *et al*. Unwarranted variation in the quality of care for patients with diseases of the thoracic aorta. *J Am Heart Assoc* 2017; **6**: e004913

Chapter 6: Cardiac surgery in the older population

Mark Jones and Mahmoud Loubani

6.1 Introduction

There have been many developments in treatments for heart disease over the last 15 years, and many of these developments have occurred at the interface between treatments that can be offered by cardiology and cardiac surgery. The population has also aged and it is a principle of NHS care that patients should not be denied treatment based on age alone. More and more older patients have therefore been referred for surgical evaluation, and it is this population where decision making about risks and benefits of different therapies can be most difficult.

It has to be noted that after decades of improvement to life expectancy, the latest figures show a slowing down in improvement. Life expectancy at birth remained at 79.2 years for men and 82.9 years for women in the last 5 years. Nevertheless, it is predicted that in 50 years' time, there will be an additional 8.2 million people aged 65 years and over in the UK.[1]

The concept of a 'heart team' is now embedded in clinical practice and multidisciplinary assessment of patients is undertaken to try to establish the best treatment option for each individual patient. Such treatments include percutaneous coronary intervention versus coronary artery bypass graft (CABG) surgery and transcatheter aortic valve implantation (TAVI) versus aortic valve replacement (AVR) but it is clear that there is continuous development.[2–6] These debates are now increasing with respect to mitral valve disease and aortovascular disease. Any trends noted in the current analysis may have relevance for healthcare planning and commissioning in the future, and these are likely to be of interest to stakeholders.

6.2 Results

6.2.1 Proportion of older patients overall

The mean age of patients undergoing cardiac surgery as recorded in the National Adult Cardiac Surgery Audit (NACSA) has shown an increase from 64 years in 2002–2003 to 66 years in 2015–2016 (Figure 37).

Figure 37
Mean age of all patients undergoing cardiac surgery

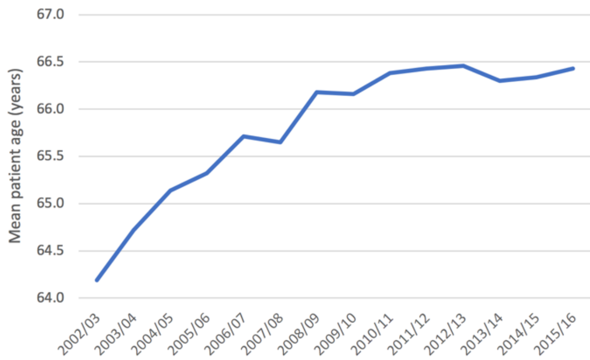
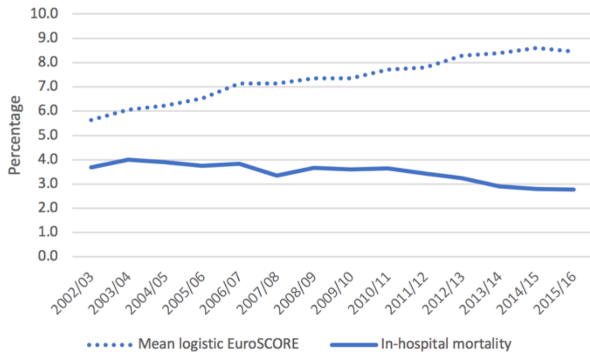


Figure 38
Mean logistic EuroSCORE and in-hospital mortality rates for all patients undergoing cardiac surgery



Age contributes to the calculation of the logistic EuroSCORE (European System for Cardiac Operative Risk Evaluation). However, older patients often have additional comorbid factors and may require more extensive operations. It is therefore not surprising that there was also an increase in the mean logistic EuroSCORE from 5.64 to 8.45 over the same time period. It is very reassuring that despite this greater risk profile of patients undergoing cardiac surgery, the outcomes in terms of mortality have improved, with the in-hospital mortality rate falling from 3.68% in 2002–2003 to 2.77% in 2015–2016 (Figure 38).

The number of patients aged <70 years undergoing cardiac surgery is falling slightly in absolute terms. When expressed as a percentage of the overall activity in NACSA, there is a progressive fall from 65% in 2002–2003 to 55% in 2015–2016 (Table 6).

There has been a slight increase in the proportion of patients aged 70–79 years and mortality has fallen over the years in this cohort (Table 7). These patients have had an increasing mean logistic EuroSCORE ranging from approximately 8 in 2002–2003 to almost 11 in 2015–2016. Despite this increasing comorbidity, the in-hospital mortality rate has fallen to only 3% in 2015–2016.

Regarding patients aged >80 years, there has been a remarkable increase from 1,444 patients in 2002–2003 (4% of overall

Table 6

Total number of procedures recorded in NACSA for patients aged <70 years

Column	Value
1	Year
2	Number of procedures in NACSA (<70 years)
3	Mean age (years)
4	Mean logistic EuroSCORE
5	Median postoperative length of stay (days)
6	In-hospital mortality rate
7	% of overall cardiac activity

1	2	3	4	5	6	7
2002/03	23,020	58.5	4.1	7	2.7%	65.0%
2003/04	23,722	58.5	4.2	7	2.8%	62.4%
2004/05	23,788	58.7	4.3	7	2.6%	60.8%
2005/06	24,652	58.8	4.5	7	2.9%	60.5%
2006/07	22,484	58.5	4.9	7	2.7%	57.9%
2007/08	23,649	58.3	4.9	7	2.2%	57.7%
2008/09	22,976	58.3	4.8	7	2.3%	55.5%
2009/10	21,317	58.1	4.8	7	2.5%	55.1%
2010/11	19,976	58.1	5.1	7	2.5%	54.5%
2011/12	20,058	58.1	5.0	7	2.4%	54.5%
2012/13	19,996	58.1	5.5	7	2.2%	54.7%
2013/14	20,621	58.1	5.6	7	2.2%	55.3%
2014/15	20,617	58.1	5.9	7	2.0%	55.2%
2015/16	19,747	58.2	5.8	7	2.3%	54.6%
Overall mean	**21,902**	**58.3**	**5.0**	**7**	**2.5%**	**57.4%**

Table 7

Total number of procedures recorded in NACSA for patients aged 70–79 years

Column	Value
1	Year
2	Number of procedures in NACSA (70–79 years)
3	Mean age (years)
4	Mean logistic EuroSCORE
5	Median postoperative length of stay (days)
6	In-hospital mortality rate
7	% of overall cardiac activity

1	2	3	4	5	6	7
2002/03	10,971	73.7	7.9	8	5.1%	31.0%
2003/04	12,282	73.9	8.5	8	5.5%	32.3%
2004/05	13,141	74.9	8.6	8	5.3%	33.6%
2005/06	13,598	74.0	8.9	8	4.7%	33.3%
2006/07	13,412	74.2	9.3	8	4.9%	34.6%
2007/08	14,160	74.2	9.3	8	4.5%	34.6%
2008/09	14,719	74.3	9.7	8	4.8%	35.5%
2009/10	13,617	74.3	9.6	8	4.5%	35.2%
2010/11	12,701	74.4	9.8	8	4.4%	34.7%
2011/12	12,681	74.4	9.9	8	4.2%	34.5%
2012/13	12,226	74.4	10.4	8	4.1%	33.5%
2013/14	12,564	74.4	10.4	8	3.4%	33.7%
2014/15	12,500	74.4	10.7	8	3.5%	33.5%
2015/16	12,516	74.3	10.6	7	3.0%	34.6%
Overall mean	**12,935**	**74.2**	**9.5**	**8**	**4.4%**	**33.9%**

activity) to a peak of 4,311 patients (12% of overall activity) in 2012–2013 with only a slight reduction in more recent years (Table 8). The mortality rate has halved during the years reviewed and it was only 4.4% in 2015–2016 despite a persistently high mean logistic EuroSCORE of approximately 14.8. The median length of stay has come down to 9 days in patients aged >80 years, and has fallen from 8 to 7 days in patients aged between 70 and 80 years while remaining static at 7 days in patients under 70 years.

The proportion of older patients with a higher risk profile as reflected by their logistic EuroSCORE has increased over the period 2002–2016. Patients over 70 years of age accounted for only 35% of the workload in 2002–2003 but this rose to 45% in 2015–2016. The difference over time for patients aged >80 years is even more striking, with the proportion having almost trebled from only 4% in 2002–2003 to 11–12% in more recent years. Mortality for these older patients is greater than for younger patients although it is reassuring that mortality rates have fallen across all age groups over time.

6.2.2 CABG in the older population

There has been a general increase in patient age for isolated CABG procedures

Table 8
Total number of procedures recorded in NACSA for patients aged >80 years

Column	Value
1	Year
2	Number of procedures in NACSA (>80 years)
3	Mean age (years)
4	Mean logistic EuroSCORE
5	Median postoperative length of stay (days)
6	In-hospital mortality rate
7	% of overall cardiac activity

1	2	3	4	5	6	7
2002/03	1,444	82.3	14.2	10	8.9%	4.1%
2003/04	2,032	82.3	13.8	10	9.4%	5.3%
2004/05	2,176	82.3	14.0	10	9.7%	5.6%
2005/06	2,534	82.5	14.7	10	7.3%	6.2%
2006/07	2,912	82.6	14.7	9	7.7%	7.5%
2007/08	3,174	82.6	14.5	10	6.8%	7.7%
2008/09	3,731	82.6	14.5	9	7.5%	9.0%
2009/10	3,744	82.7	14.4	10	6.5%	9.7%
2010/11	3,971	82.7	14.9	10	6.7%	10.8%
2011/12	4,050	82.6	15.2	9	6.0%	11.0%
2012/13	4,311	82.7	15.4	10	5.7%	11.8%
2013/14	4,130	82.6	16.2	9	5.3%	11.1%
2014/15	4,244	82.7	16.0	9	4.8%	11.4%
2015/16	3,903	82.6	15.0	9	4.4%	10.8%
Overall mean	**3,311**	**82.6**	**14.8**	**10**	**6.9%**	**8.7%**

Table 9
Total number of isolated CABG procedures performed

Column	Value
1	Year
2	Total number of isolated CABG procedures
3	Mean age (years)
4	Mean logistic EuroSCORE
5	Median postoperative length of stay (days)
6	In-hospital mortality rate
7	% of overall cardiac activity

1	2	3	4	5	6	7
2002/03	23,605	64.4	3.8	7	2.1%	66.6%
2003/04	24,335	64.9	4.1	7	2.2%	64.0%
2004/05	24,565	65.2	4.2	7	2.2%	62.8%
2005/06	24,316	65.4	4.2	7	1.8%	59.6%
2006/07	22,233	65.8	4.6	7	2.0%	57.3%
2007/08	23,407	65.7	4.6	6	1.6%	57.1%
2008/09	22,159	66.0	4.6	6	1.7%	53.5%
2009/10	20,156	66.1	4.7	6	1.8%	52.1%
2010/11	18,616	66.2	4.8	6	1.8%	50.8%
2011/12	16,895	66.0	4.8	6	1.5%	45.9%
2012/13	16,210	66.1	5.1	7	1.5%	44.4%
2013/14	15,712	66.0	5.0	6	1.6%	42.1%
2014/15	15,596	65.9	4.9	6	1.2%	41.7%
2015/16	15,078	66.1	4.6	6	1.0%	41.7%
Overall mean	**20,206**	**65.7**	**4.6**	**6**	**1.7%**	**52.8%**

although this appears to have plateaued (Table 9). It seems that the age of patients undergoing elective CABG is continuing to rise while that of patients requiring urgent CABG seemed to peak in 2010–2011 and has fallen slightly since then. The mortality figures are improving despite the increased age. Although the absolute numbers of emergency CABG are much lower and are continuing to fall, the mean age and number of cases peaked in 2007–2008, and have declined since then (with some fluctuations). The number of salvage CABG cases is very small and does not show a clear trend regarding age.

The number of patients aged <70 years undergoing CABG has fallen from 15,963 (67% of activity) in 2002–2003 to 9,092 (60% of activity) in 2015–2016. It is possible that a clinical practice strategy could account for this fall in younger patients undergoing CABG, in favour of initial percutaneous coronary intervention and deferring cardiac surgery until patients are older. However, there has been a slight reduction in patients aged 70–79 years undergoing CABG although the proportions have not shown much variation over the years. There has been a reduction in mortality for this cohort.

Although patients aged >80 years only represent a small proportion of the total number of those undergoing isolated CABG, the numbers have risen over the period reviewed here, with the highest proportions (8% in 2012–2013) and numbers (1,362 patients in 2009–2010) occurring between 2009 and 2013 (Table 10). Mortality has also improved in this cohort over the years. The median length of stay has fallen slightly for these patients to 8 days whereas it remained static at 7 days for those aged 70–79 years and 6 days for those aged <70 years.

6.2.3 Valve surgery in the older population

The total number of valve operations performed is generally increasing although it was static in the last couple of years reported (Table 11). The average patient age has increased but it also appears to have stabilised and the mortality outcomes have been steadily improving, with a recent plateau.

The proportion of patients aged <70 years undergoing an isolated valve procedure has fallen from 63% in 2002–2003 to 50% in 2015–2016. Mortality has improved and the median postoperative length of stay has fallen from 8 to 7 days.

Table 10

Number of isolated CABG procedures performed for patients aged >80 years

Column	Value
1	Year
2	Number of isolated CABG procedures (>80 years)
3	Mean age (years)
4	Mean logistic EuroSCORE
5	Median postoperative length of stay (days)
6	In-hospital mortality rate
7	% of all isolated CABG activity

1	2	3	4	5	6	7
2002/03	587	82.0	11.0	9	6.3%	2.5%
2003/04	849	81.9	11.3	9	7.9%	3.5%
2004/05	856	81.9	10.6	9	6.0%	3.5%
2005/06	985	82.1	12.0	9	6.0%	4.1%
2006/07	1,054	82.2	12.1	8	6.2%	4.7%
2007/08	1,209	82.1	12.2	8	4.7%	5.2%
2008/09	1,297	82.2	11.0	8	5.8%	5.9%
2009/10	1,362	82.4	11.6	9	5.7%	6.8%
2010/11	1,351	82.3	11.9	8	4.9%	7.3%
2011/12	1,230	82.3	12.4	9	4.7%	7.3%
2012/13	1,289	82.3	12.5	9	4.0%	8.0%
2013/14	1,150	82.2	12.8	8	4.2%	7.3%
2014/15	1,058	82.3	12.4	8	3.3%	6.8%
2015/16	1,076	82.3	11.6	8	3.5%	7.1%
Overall mean	**1,097**	**82.2**	**11.8**	**9**	**5.2%**	**5.7%**

There has been an increase in the proportion of patients aged 70–79 years having an isolated valve procedure with a halving of the mortality rate despite the mean logistic EuroSCORE remaining similar. The number and proportion of patients aged >80 years having isolated valve procedures has increased but despite this, postoperative length of stay and mortality have fallen. It is unclear whether the numbers are stabilising as there seems to be small fluctuation around these patients, who now contribute 14–15% of overall isolated valve activity (Table 12).

TAVI was reserved initially for a high-risk cohort of patients and many of these were older but there is increasing discussion regarding the validity of utilising TAVI in patients with severe aortic stenosis at intermediate and low risk.[5,6] The opportunity of a choice between TAVI or conventional AVR may have influenced the number and age of patients undergoing AVR in the latter half of this audit series. Another more recent consideration is the availability of rapid deployment valves, which may affect decision making around the choice of prosthesis in older patients undergoing aortic valve surgery.[7,8]

The mean age of patients who are over 80 years old undergoing isolated valve surgery has remained relatively constant, with the majority being in their early 80s. Nevertheless, it is striking to note that this

Table 11
Total number of valve procedures performed

Column	Value
1	Year
2	Total number of valve procedures
3	Mean age (years)
4	Mean logistic EuroSCORE
5	Median postoperative length of stay (days)
6	In-hospital mortality rate
7	% of overall cardiac activity

1	2	3	4	5	6	7
2002/03	10,242	65.1	9.0	9	5.9%	28.9%
2003/04	11,768	65.6	9.2	9	6.2%	30.9%
2004/05	12,583	66.1	9.5	9	5.9%	32.2%
2005/06	14,359	66.2	9.8	9	5.9%	35.2%
2006/07	14,338	66.6	10.2	9	5.7%	37.0%
2007/08	15,223	66.5	10.2	8	5.2%	37.1%
2008/09	16,673	67.2	10.2	8	5.0%	40.3%
2009/10	16,000	67.2	10.0	8	4.6%	41.4%
2010/11	15,550	67.6	10.4	8	4.9%	42.4%
2011/12	16,099	67.7	10.4	8	4.3%	43.8%
2012/13	16,543	67.8	10.7	8	4.3%	45.3%
2013/14	16,822	67.6	11.2	8	3.7%	45.1%
2014/15	17,494	67.7	10.9	8	3.6%	46.8%
2015/16	17,486	67.6	10.2	8	3.6%	48.4%
Overall mean	**15,084**	**66.9**	**10.1**	**8**	**4.9%**	**39.6%**

Table 12
Number of isolated valve procedures performed for patients aged >80 years

Column	Value
1	Year
2	Number of isolated valve procedures (>80 years)
3	Mean age (years)
4	Mean logistic EuroSCORE
5	Median postoperative length of stay (days)
6	In-hospital mortality rate
7	% of all isolated valve activity

1	2	3	4	5	6	7
2002/03	434	82.4	14.8	10	6.9%	6.8%
2003/04	553	82.5	13.9	10	7.4%	7.7%
2004/05	652	82.7	15.4	10	10.4%	8.8%
2005/06	751	83.0	14.0	10	4.5%	9.3%
2006/07	804	83.0	14.8	9	6.3%	10.2%
2007/08	828	83.0	15.1	10	6.2%	9.7%
2008/09	1,094	83.0	15.9	10	6.9%	11.8%
2009/10	1,063	83.0	15.0	10	5.0%	11.8%
2010/11	1,191	82.9	15.4	9	5.2%	14.0%
2011/12	1,158	82.9	14.8	10	4.5%	14.2%
2012/13	1,253	82.9	15.8	9	5.0%	15.4%
2013/14	1,181	82.7	16.8	9	3.7%	14.7%
2014/15	1,351	82.9	15.9	9	3.2%	15.7%
2015/16	1,265	82.8	13.8	9	3.1%	13.9%
Overall mean	**970**	**82.8**	**15.1**	**10**	**5.6%**	**11.7%**

older cohort of patients contributes approximately 14–15% of all isolated valve activity by the end of the time reviewed, a rate that is roughly double that from 2002–2003. It is also worth highlighting that the mortality rate has halved, down to 3% in 2015–2016, despite a consistently high logistic EuroSCORE during this period. Length of hospital stay has fallen by only one day down to 9 days for these patients, who have significant comorbidities.

The age and number of patients undergoing AVR shows a general increase although this may have stabilised in the most recent years. It is interesting to note that the number of isolated AVRs rose to a peak in 2008–2009 and then fell. It is uncertain whether this figure is rising again or simply fluctuating around a proportion of overall activity of 12–14%.

The age of patients undergoing any mitral procedure shows an increase at the end of the period reviewed. Mitral repairs appear to be increasing over time and the mean age of patients has also increased. Mitral surgery is discussed in more detail in *Chapter 4: Mitral valve surgery*.

6.2.4 Combined CABG and valve surgery

It is not surprising that the mean age of patients undergoing combined CABG and valve procedures is greater at 72 years than for either isolated CABG (mean age 66 years) or isolated valve procedures (mean age 65 years). The trend over time also appears to show a gradual increase from 70 years at the beginning to 72–73 years at the end (Table 13).

6.2.5 Thoracic aorta

The number of patients undergoing aortic procedures has increased and the mean age is also increasing. Aortic surgery is discussed in more detail in *Chapter 5: Major aortic surgery*.

6.2.6 Redo surgery

The number of patients undergoing ‘redo’ procedures is falling but the age of those operated on as a redo is increasing. There is considerable variation in logistic EuroSCORE but operative mortality is falling with time despite the increased age. Redo CABG patients are younger than those undergoing redo valve procedures, with a lower logistic EuroSCORE but higher mortality than redo valve cases.

6.3 Conclusions

The mean age of patients undergoing cardiac surgery as recorded in NACSA has

Table 13
Number of combined CABG and valve procedures performed

Column	Value
1	Year
2	Number of combined CABG and valve procedures
3	Mean age (years)
4	Mean logistic EuroSCORE
5	Median postoperative length of stay (days)
6	In-hospital mortality rate
7	% of overall cardiac activity

1	2	3	4	5	6	7
2002/03	3,274	70.2	9.9	9	7.9%	9.2%
2003/04	3,842	70.8	9.8	9	7.9%	10.1%
2004/05	4,063	70.9	9.9	9	6.9%	10.4%
2005/06	4,766	70.7	11.1	10	8.3%	11.7%
2006/07	4,707	71.3	11.1	9	7.0%	12.1%
2007/08	4,769	71.9	10.7	9	6.6%	11.6%
2008/09	5,194	72.3	10.8	9	6.1%	12.5%
2009/10	4,870	72.4	10.8	9	6.2%	12.6%
2010/11	4,592	72.7	11.1	9	5.8%	12.5%
2011/12	4,202	72.7	10.8	9	4.9%	11.4%
2012/13	4,403	73.0	10.5	9	5.0%	12.1%
2013/14	4,098	72.9	11.8	9	4.2%	11.0%
2014/15	4,216	73.0	11.5	9	3.9%	11.3%
2015/16	4,113	72.6	10.6	8	4.0%	11.4%
Overall mean	**4,365**	**72.0**	**10.7**	**9**	**6.1%**	**11.4%**

increased by two years over the period reviewed up to 66 years in 2016. There has been a slight increase in the proportion of patients aged 70–79 years and mortality has fallen over the years in this cohort. Even with increasing comorbidity, the in-hospital mortality rate has fallen to only 3% in 2015–2016. There has also been a remarkable increase in patients aged >80 years undergoing cardiac surgery. The mortality rate has halved and was only 4.4% in 2015–2016 despite a persistently high mean logistic EuroSCORE of approximately 14.8. These older patients require longer postoperative stays of 9–10 days (and therefore an increase in resources) compared with a length of stay several days shorter for younger patients.

The patterns are consistent regardless of whether patients are undergoing CABG, valve or combined CABG and valve surgery. The latter group are an older patient cohort, making up a significant proportion of the workload, and while outcomes in terms of mortality are excellent, they too require a significant postoperative hospital stay.[9]

Interventions such as percutaneous coronary intervention, TAVI and rapid deployment valves undoubtedly have an effect on decision making as to the optimal treatment strategy for any individual patient but may also result in patients now being referred for cardiac surgery who may not have been considered in the past. It is likely that the impact of these less invasive options will increase in the next 15 years.

Some international comparisons are possible. The Society of Thoracic Surgeons database demonstrates the increased numbers of patients undergoing TAVI (or transcatheter aortic valve replacement).[2] It also appears that there is some reduction in patients having isolated surgical AVR and combined AVR and CABG procedures.

In the SWEDEHEART (Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies) 2016 annual report, the proportion of patients aged >70 years is similar to that in the UK and Ireland but the proportion of >80-year-old patients undergoing cardiac surgery is higher in the UK and Ireland.[10]

References

1. Office for National Statistics. *Overview of the UK Population: August 2019*. Newport; ONS; 2019
2. D'Agostino RS, Jacobs JP, Badhwar V *et al*. The Society of Thoracic Surgeons Adult Cardiac Surgery Database: 2018 update on outcomes and quality. *Ann Thorac Surg* 2018; **105**: 15–23
3. Thuijs DJ, Kappetein AP, Serruys PW *et al*. Percutaneous coronary intervention versus coronary artery bypass grafting in patients with three-vessel or left main coronary artery disease: 10-year follow-up of the multicentre randomised controlled SYNTAX trial. *Lancet* 2019; **394**: 1325–1334
4. Stone GW, Kappetein AP, Sabik JF *et al*. Five-year outcomes after PCI or CABG for left main coronary disease. *N Engl J Med* 2019; **381**: 1820–1830
5. Leon MB, Smith CR, Mack MJ *et al*. Transcatheter or surgical aortic-valve replacement in intermediate-risk patients. *N Engl J Med* 2016; **374**: 1609–1620
6. Baron SJ, Wang K, House JA *et al*. Cost-effectiveness of transcatheter versus surgical aortic valve replacement in patients with severe aortic stenosis at

intermediate risk. *Circulation* 2019; **139**: 877–888

7. Liakopoulos OJ, Gerfer S, Weider S *et al*. Direct comparison of the Edwards Intuity Elite and Sorin Perceval S rapid deployment aortic valves. *Ann Thorac Surg* 2018; **105**: 108–114
8. Berretta P, Andreas M, Carrel TP *et al*. Minimally invasive aortic valve replacement with sutureless and rapid deployment valves: a report from an international registry (Sutureless and Rapid Deployment International Registry). *Eur J Cardiothorac Surg* 2019; **56**: 793–799
9. Habib AM, Hussain A, Jarvis M *et al*. Changing clinical profiles and in-hospital outcomes of octogenarians undergoing cardiac surgery over 18 years: a single-centre experience. *Interact Cardiovasc Thorac Surg* 2019; **28**: 602–606
10. *SWEDEHEART Annual Report 2016*. Stockholm: Karolinska Institute; 2017

Chapter 7: Rare operations

Simon Kendall and Samer Nashef

7.1 Introduction

The overwhelming majority of heart operations in adults comprises first-time coronary artery bypass graft (CABG) operations, aortic or mitral valve surgery, various combinations of these valve operations plus CABG and, of course, surgery on the thoracic aorta. A number of other, less common major heart operations are also performed and taken together, they account for less than 10% of all heart operations. Among these procedures are 'redo' cardiac surgery, pericardiectomy, surgery on the tricuspid valve, removal of cardiac tumours and surgery for post-infarction ventricular septal rupture. As they are relatively infrequent, little can be learnt from individual centre data since some of these procedures may only be carried out a few times per year but the national database with more than a decade of data provides a unique opportunity to examine the frequency and outcomes of such procedures.

7.1.1 All redo surgery

An operation is considered a redo procedure if the patient has had a previous major heart operation at some point in life, even as an infant. This will have usually been performed through a median sternotomy but the term also applies to patients who have had heart surgery through other incisions, such as thoracotomy, mini-sternotomy or mini-thoracotomy.

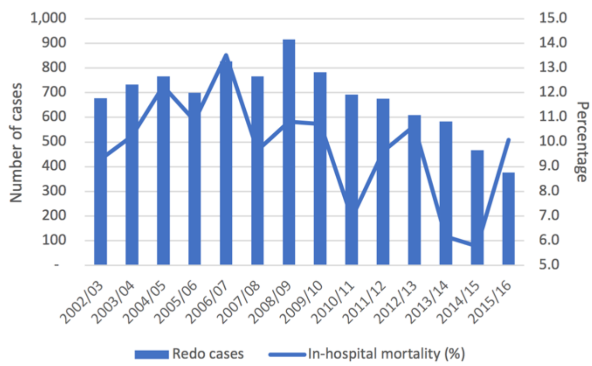
At a first-time operation, the heart is usually beating freely in the pericardial sac, making access easy. In a redo operation, the heart will be densely adherent to the pericardium and surrounding structures, making the surgery much more challenging, with the inherent risk of injuring the heart or entering a cardiac chamber being present from the time of sternotomy until the heart is freed of all adhesions. If the previous cardiac operation was a coronary bypass, there is the additional risk of injuring the coronary grafts, on which survival of the heart muscle (and of the patient) may depend. If it was a valve replacement, removing a well-embedded prosthetic valve can be difficult.

Great care must be taken while opening the chest to avoid damaging the heart and other structures. When the risk of resternotomy is deemed exceptionally high, preparations can be made for cardiopulmonary bypass to be established rapidly using peripheral cannulation (femoral/axillary/jugular vessels) and, in the most hazardous cases, even instituted before the resternotomy is made.

Redo cardiac surgery peaked at 915 operations per annum in 2008–2009 and

Figure 39

Case volumes and in-hospital mortality rates for cardiac redo procedures



has been falling steadily since, to under 400 operations in 2015–2016, well below half the numbers at the peak and only accounting for 1% of cardiac surgical activity (Figure 39). Reasons for this fall are difficult to ascertain but probably include better longevity of the primary heart operation and the increasing availability of cardiological intervention to tackle specific lesions without the need to reopen the chest. The mortality rate from redo operations remains relatively high at around 10% overall. The lowest rate of around 6% was achieved in 2013–2015 but this was not maintained in 2016, when it regressed to the mean.

7.1.2 Pericardiectomy

The normally flexible pericardium, with its slippery surface and a small amount of fluid, is essential for the heart to move freely. Rarely, viral or bacterial infections or inflammatory conditions (as a result of autoimmune disease, infarction, trauma or previous cardiac surgery) will cause the pericardium to thicken, fibrose and even calcify. This transforms the normally 1mm thin and flexible membrane into an unwieldy 'straightjacket', up to 1cm thick, around the heart. This is pericardial constriction and can seriously compromise the heart's pumping function, especially its ability to relax in diastole to fill up with blood. The result is the haemodynamic equivalent of failure of both ventricles, with breathlessness and peripheral oedema as the usual presenting features.

Diagnosis can be difficult, particularly in distinguishing constriction from restrictive cardiomyopathy and diastolic dysfunction.[1] Once the diagnosis is firmly established, the constriction can be relieved by pericardiectomy, an operation to separate and remove the diseased and constricting pericardium from the heart. Of course, in such patients, there is no gap between heart and pericardium, and it is difficult to define where the pericardium ends and the heart begins; consequently, the surgery to remove this straightjacket can be challenging. This is often done without cardiopulmonary bypass to reduce the risk of bleeding from raw surfaces. However, in especially complex cases or when other cardiac lesions coexist and need concomitant correction, bypass may have to be used.

Pericardiectomy remains a relatively rarely performed operation with only 100 procedures carried out per year. The patient cohort is younger, with an average age of 57 years. There is evidence of significant and impressive improvement in outcomes, with the mortality rate falling from 16% in 2002–2006 to around 4% in 2013–2016 despite the average logistic EuroSCORE (European System for Cardiac Operative Risk Evaluation) increasing from 5 to 7.5 and the average age increasing from 53 to 59 years, comparing well with other national series.[2]

7.1.3 Isolated tricuspid valve surgery

Of the four cardiac valves, the valve most commonly needing intervention is the aortic valve followed by the mitral valve. It is extremely rare that the pulmonary valve ever needs intervention in adult patients. The tricuspid valve may occasionally need repair by annuloplasty in conjunction with mitral valve surgery but otherwise, it rarely requires surgery as an isolated procedure, which is the focus of this section. In broad terms, the tricuspid valve may need surgery when infected in relatively young patients who abuse intravenous drugs or in older patients who have dilated right ventricles causing functional regurgitation. The higher mortality reflects the nature of the underlying infection in younger patients or the right ventricular failure in older patients.

There are on average fewer than 60 cases of isolated tricuspid valve surgery cases per annum but the mortality rate has halved from 20% in 2002–2007 to less than 10% in 2011–2016 (Figure 40). The average patient age is 54 years, which may reflect the merging of two distinct peaks representing the two cohorts of younger intravenous drug abusers and older patients with functional tricuspid regurgitation or damage due to pacing leads. The logistic EuroSCORE has largely matched the change in mortality and the median postoperative length of stay is now 8 days.

Figure 40
Case volumes and in-hospital mortality rates for isolated tricuspid valve procedures

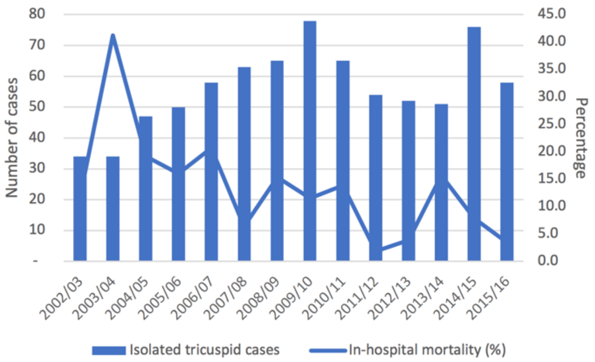
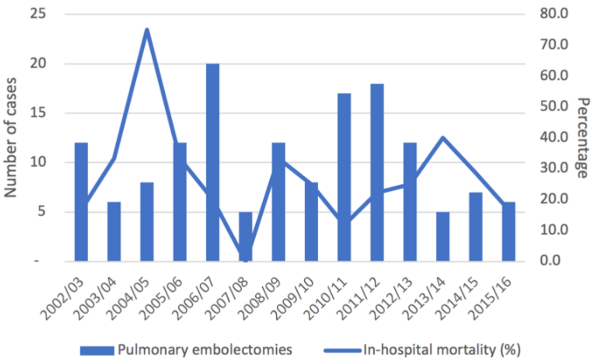


Figure 41
Case volumes and in-hospital mortality rates for pulmonary embolectomies



7.1.4 Pulmonary embolectomy

A pulmonary embolus is a blood clot that has usually originated in the veins of the lower body. The clot breaks off and the flow of blood carries it through the right heart into the pulmonary arteries in the lungs.

Most pulmonary emboli are relatively small and treatment is by simple anticoagulation. Larger emboli can be managed by thrombolysis and this is the guideline-recommended first-line treatment when there is evidence of haemodynamic compromise. Very occasionally, massive embolism can occlude most or all of the pulmonary circulation and cause instant death or haemodynamic compromise so severe that without emergency or salvage intervention, the patient will die. It is in these kinds of rare circumstances that surgery may be indicated as an emergency to save life. It can also be the only way out in patients for whom thrombolysis is absolutely contraindicated, such as after very recent major surgery or childbirth. It remains the quickest means to clear the clot and restore cardiac output.

Pulmonary embolectomy is carried out on cardiopulmonary bypass, and the clots are simply removed from the pulmonary artery and its major branches. The results are not encouraging, possibly reflecting the parlous state of these patients when they arrive in the operating theatre, the fact that some may well have presented with acute-on-chronic embolism and that further emboli may still develop during the postoperative period if clots remain a risk in the systemic venous circulation. The in-hospital mortality rate is high but it has to borne in mind that without such interventions in appropriate cases, death usually follows. Despite the guidelines favouring thrombolysis, more recent series have indicated that surgery does have a role in the modern era, especially for the sickest patients with shock and a saddle embolism.

Pulmonary embolectomy is a rarely performed emergency procedure with only about ten operations per annum reported in the database (Figure 41). The average age of patients is 52 years and, as a procedure performed only sporadically, mortality varies widely between years from a high of 75% to a low of 0%, with an average mortality of approximately 30%. The mean hospital stay is 12 days. These results are similar to those reported in a larger series of pulmonary embolectomy operations from the national inpatient sample in the US between 2010 and 2014, with a 20% mortality rate.[3]

7.1.5 Cardiac tumours

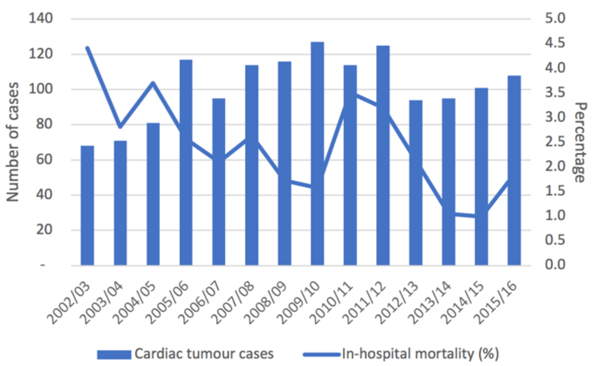
Tumours of the heart are very rare and when they do occur, they are often local spread from lung cancer nearby or metastatic deposits from malignant tumours elsewhere in the body. The most common primary cardiac tumour is a myxoma, usually found in the left atrium, usually arising from the septum, although right atrial myxoma is also recognised. Myxomas are friable and pose an embolic risk; indeed, they are sometimes discovered after an embolic event although they are now more frequently picked up as an incidental finding on echocardiography. The second most common primary tumour is a small fibroelastoma, often associated with valve leaflets or other parts of the endocardium. Malignant tumours, such as sarcomas, are exceedingly rare.

Operations to remove myxomas and fibroelastomas are usually straightforward, low-risk procedures whereas operations attempting to excise malignant tumours are high-risk and rarely achieve cure. The national data include all of these in the category of cardiac tumours and the results are a reflection of a mix of mostly simple myxoma operations interspersed with occasional high-risk malignant tumour surgery. In the past, myxoma operations were performed as an emergency but it is now accepted that such tumours will have been present for years and urgent or priority elective listing is acceptable.

There has been a gradual increase in the number of operations performed, partly due to greater availability and use of echocardiography. Mortality rates have fallen steadily by around half from over 4% to approximately 2% (Figure 42). Length of stay is around 7 days.

Figure 42

Case volumes and in-hospital mortality rates for cardiac tumour operations



7.1.6 Cardiac trauma

Review of cardiothoracic trauma in the UK and Ireland shows that the vast majority of cases can be treated conservatively (with or without a chest drain). If surgery is required, it is usually for thoracic trauma using a thoracotomy.

Trauma can be blunt (crush or deceleration injury) or penetrating (knife or bullet wounds). Aortic transection was one complication of blunt trauma that used to be treated with open surgery but the advent of covered stents has largely eliminated this procedure from the surgical repertoire. Emergency cardiac surgery for other blunt trauma is rarely successful and is not a recommended intervention. Penetrating trauma to a cardiac chamber (such as a stab wound) can lead to bleeding or tamponade and often mandates emergency surgery to repair the injury and save the patient. Depending on the desired access and instruments available, this can be by sternotomy, thoracotomy or a 'clamshell' double thoracotomy incision. This may be performed in the accident and emergency department but, where possible, it is best done in a cardiothoracic theatre.

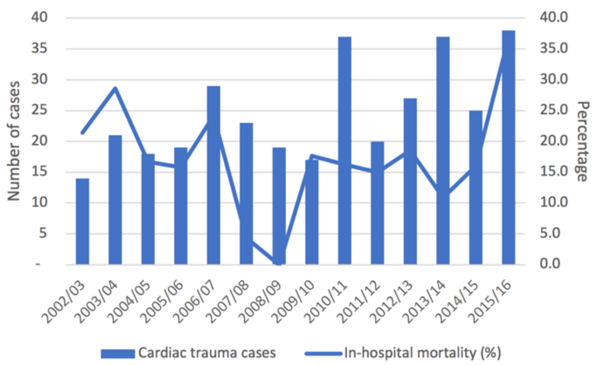
Figure 43 shows the number of operations performed per year for cardiac trauma and the associated mortality rates. The mean in-hospital mortality rate was 17.3%. It is difficult to draw many conclusions from these data as they contain several types of cardiac trauma and may be associated with other serious injury. Survival is likely to depend more on the state of the patient on presentation (which may vary from stable to 'dead but still warm'), the extent of cardiac damage and the presence of other life-threatening injury.

7.1.7 Surgery for complications of myocardial infarction

Heart muscle that has been damaged by myocardial infarction can give way. If this

Figure 43

Case volumes and in-hospital mortality rates for cardiac trauma



occurs in the ventricular septum, an ischaemic ventricular septal defect (or septal rupture) is the result. Depending on the culprit coronary artery, the rupture can be anterior or inferior and leads to a large left-to-right shunt with cardiac failure followed by multiorgan failure. Without early surgery to repair the defect, the outcome is usually fatal. The patient is supported with an intra-aortic balloon pump for a few hours or days before proceeding and decisions on the optimal time to intervene can be difficult.[4]

Surgery is extremely challenging as the edges of the defect are within dead muscle that has no intrinsic strength to hold repair sutures and re-rupture can occur soon afterwards. The combination of a major infarct with the ravages of the septal disruption and emergency surgery can prove too onerous for the heart and the patient, and the mortality rate is high. The incidence of such operations has fallen somewhat over the last 15 years and this may be related to the introduction of primary coronary intervention for myocardial infarction, which is believed to reduce the immediate muscle damage by restoring coronary flow at an early stage.

If the dead heart muscle that gives way involves the papillary muscles supporting the mitral valve, acute and catastrophic mitral regurgitation can be the result. This, like ventricular septal rupture, also requires intra-aortic balloon pump support followed by early surgery to repair or, more often, replace the mitral valve. The challenges faced by the heart in such conditions are similar to those of ventricular septal rupture and the mortality rate is also high.

Occasionally, the area of dead heart muscle that gives way is in the free wall, leading to massive bleeding into the pericardial sac with tamponade and death. If the patient survives to hospital admission, drainage of tamponade with or without attention to the disruption may save some lives.

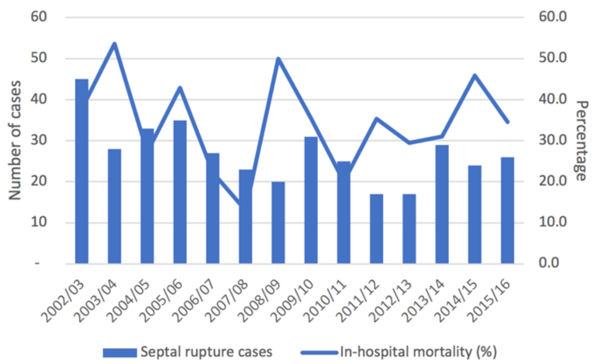
Since a peak of 45 operations for septal rupture in 2002–2003, the annual number is now down to around 25 (Figure 44). Re-rupture is not uncommon and the mortality rate remains high at approximately 35% but compares favourably with that reported by the Society of Thoracic Surgeons national database of 42%[5] and other series reporting 30-day mortality rates of 39–80%.[6,7] Length of stay varies from year to year but remains prolonged at 2–3 weeks.

7.2 Discussion

Most cardiac surgery follows well-established, protocol-driven and proven pathways. Rare cardiac conditions and the operations that aim to correct them can be more demanding in terms of diagnosis, decision making, timing of intervention and the techniques adopted. This is one area where a collegiate approach is especially useful in improving outcomes, and individual surgeons can benefit from the additional experience of their colleagues locally and beyond. Overall, the results of such interventions as reported in the SCTS national database have been excellent and compare well with international standards.

Figure 44

Case volumes and in-hospital mortality rates for septal rupture



References

1. Garcia MJ. Constrictive pericarditis versus restrictive cardiomyopathy? *J Am Coll Cardiol* 2016; **67**: 2061–2076
2. Tokuda Y, Miyata H, Motomura N *et al*. Outcome of pericardiectomy for constrictive pericarditis in Japan: a nationwide outcome study. *Ann Thorac Surg* 2013; **96**: 571–576
3. Percy ED, Shah R, Hirji S *et al*. National outcomes of surgical embolectomy for acute pulmonary embolism. *Ann Thorac Surg* 2020; **110**: 441–447
4. Papalexopoulou N, Young CP, Attia RQ. What is the best timing of surgery in patients with post-infarct ventricular septal rupture? *Interact Cardiovasc Thorac Surg* 2013; **16**: 193–196
5. Arnaoutakis GJ, Zhao Y, George TJ *et al*. Surgical repair of ventricular septal defect after myocardial infarction: outcomes from the Society of Thoracic Surgeons National Database. *Ann Thoracic Surg* 2012; **94**: 436–443
6. Pang PY, Sin YK, Lim CH *et al*. Outcome and survival analysis of surgical repair of post-infarction ventricular septal rupture. *J Cardiothorac Surg* 2013; **8**: 44
7. Pradhan A, Jain N, Cassese S *et al*. Incidence and predictors of 30-day mortality in patients with ventricular septal rupture complicating acute myocardial infarction. *Heart Asia* 2018; **10**: e011062

Chapter 8: The effect of outcomes reporting on cardiac surgery

David Jenkins and Graham Cooper

8.1 Introduction

Surgeon-specific adult cardiac surgical activity and mortality have been published in one form or another in the UK since 2005, following the recommendations of the Bristol Royal Infirmary Inquiry in 2001. The inquiry exposed that there had been some knowledge in the profession that the results of certain congenital operations at Bristol were worse than at other hospitals but there was not a mechanism to voice these concerns and the public was unaware. Consequently, the public lost trust in the profession.

Although the Bristol public inquiry related to congenital heart surgery, it was adult cardiac surgery that was first to publish surgeon-specific mortality and this was aimed at regaining public confidence.[1] By 2013, with the expansion of NHS England's Consultant Outcomes Publication programme, other specialties published outcomes for individual consultants. Despite the obvious importance of transparency to the public and the accepted value of professionals sharing information, publication of surgeon-specific data remains controversial as it focuses apparent responsibility for the complex care that a patient receives from a multidisciplinary professional team on a single individual.

Cardiac surgery already had a respected history of data collection, audit and reporting since the voluntary UK register started in 1977. This is fundamentally because of the ability to measure a single objective end point that is relevant to the patient's disease and the surgical intervention (i.e. in-hospital death), and more recently, the advent of risk stratification scores that can account for differences in patient case mix and allow fairer comparisons.

Data collection and outcomes reporting have evolved over the time period reviewed here. When the SCTS-controlled registry commenced in 1977, outcomes data were initially reported to professionals only at national level, at annual business meetings of the SCTS. The voluntary registry was replaced by a more comprehensive adult cardiac surgery database controlled by the SCTS and this dataset became more detailed from 1994.[1] From 1997, the SCTS gained members' approval for hospitals to include named surgeon mortality data for marker operations, with an aspiration for an internal scrutiny and governance mechanism. However, at the time, many units did not have the capability to provide a complete enough dataset to allow the necessary risk adjustment.

Outcomes reporting for cardiac surgery gained more public attention from 2001. It was at this time that *The Times* started reporting hospital guides and ranked hospitals by survival following cardiac surgery based on data from Dr Foster that were derived from Hospital Episode Statistics database and that were not adequately risk stratified.

In October 2002, the SCTS published unadjusted mortality data for the indicator operations of coronary artery bypass graft (CABG) and aortic valve replacement at hospital level for the first time. Importantly, as part of the government response to the Bristol inquiry, the Secretary of State for Health stipulated that from April 2002, collection of the SCTS dataset would be mandatory for all cardiothoracic hospitals in the UK and that the Central Cardiac Audit Database would be developed to host the data. This then became the National Adult Cardiac Surgery Audit from 2005 and when the National Institute for Cardiovascular Outcomes Research (NICOR)[2] was developed, the remit for data collection and analysis was transferred from the SCTS to NICOR in 2011. There was therefore a transition from what began as a voluntary, specialist society-controlled registry to a compulsory, comprehensive, externally hosted database, with an associated increase in governance processes.

In addition, over the years, there was a successive increase in data released into the public domain. A fundamental change occurred in 2005, when *The Guardian* submitted an application under the new freedom of information law to see the mortality of individual cardiac surgeons. The SCTS had already been negotiating with the government about publication of surgeon-specific data since 2001 but this had still not happened as there were ongoing debates about data quality, validation, risk adjustment, what data to publish and where. The SCTS cooperated with the media request and in 2005, risk-adjusted mortality data for aortic valve replacement and CABG operations were first published for all individual cardiac surgeons in the UK.[3]

A further element of statistical certainty was added to the publication from 2008 with identification of 99.8% control lines to demonstrate expected performance. In 2009, this evolved to publishing outcomes for all cardiac surgery at surgeon level using the recalibrated logistic EuroSCORE (European System for Cardiac Operative Risk Evaluation)[4] risk adjustment methodology. From 2013, there was a national drive to also report consultant outcomes for other surgical specialties, led by the Medical Director of the NHS.

Following the *Guardian* freedom of information request, the outcomes were initially reported on the Care Quality Commission website and after this was decommissioned, the SCTS hosted the data on its own website from 2009. In 2014, alongside other consultant outcomes data, cardiac surgery mortality for individual consultants appeared on the NHS Choices website with links to more detailed information on the SCTS website.[5] The graphical displays of this information, the risk adjustment processes and the statistics around identification of those hospitals and individual surgeons with outcomes better, or worse, than expected ('outliers') all evolved during this period.

This system of national cardiac surgery audit in the UK incorporates compulsory reporting of all NHS cardiac surgical operations. The national cohort reported here therefore includes complete case attainment of every cardiac operation performed. Risk stratification has partly reassured clinicians that it is valid to publish their risk-adjusted outcomes and allow comparison with the performance of others. Currently, in the UK and Ireland, risk stratification is based on a modified and recalibrated logistic EuroSCORE that describes the risk of a procedure for an individual patient relatively accurately. However, added to this is perhaps the most controversial but also potentially the most important element in terms of governance, benchmarking and quality improvement: statistical analysis to describe average performance and outlier performance.

Publication of these data provides the public with confidence that cardiac surgery in the UK and Ireland produces consistently good survival, and that there are no hidden poorly performing hospitals or surgeons. Owing to the comprehensive and complete data collection because of mandatory (rather than voluntary) reporting, and publication of hospital/surgeon-specific results, this reassurance about the national safety of adult cardiac surgery in the UK and Ireland is unique in the world. The impact of this analysis over the longer term on national outcomes and individual surgeons has not previously been examined and published.

Despite the possible benefits outlined above, there are also potential detrimental effects from surgeon-specific outcomes reporting. These include risk-averse behaviour, distortion of priorities to meet targets, concentration on more measurable performance indicators only and manipulation of data to improve apparent performance. The issue that has given most cause for concern among clinicians has been that of selection inequity (risk-averse behaviour). This occurs if a surgeon chooses not to operate on a patient perceived to be at risk of a poor outcome in order to improve the surgeon's results. In adult cardiac surgery, emergency surgery is excluded from outcomes reporting so this should not be a factor influencing decision making for the very sickest patients.[6]

The issue of risk-averse behaviour in surgery is complex and not simply related to the publication of individual surgeon outcomes. Nevertheless, there is a perception in adult cardiac surgery and other surgical specialties that publication of individual surgical outcomes has heightened this. A counterargument is that scrutiny of individual outcomes may deter a surgeon from cavalier behaviour and make sure that due thought is given to the risk/benefit of every intervention for every patient.

Other potential problems include overreliance on statistics and decisions about where to set control limits for outlier reporting. For example, what is a clinically important difference? Two, three or even four standard deviations from the norm? The concept of the false discovery rate is also important to understand and incorporate. Eventually, after internal SCTS discussions, debate with member surgeons and having received the best statistical advice, it was decided that surgeons would only be identified in the public domain as 'below expected' when the 99.8% limit (3 standard deviations) was reached. It was accepted that surgeons and hospitals should be informed to review their practice if the 95% limit (2 standard deviations) was reached but as there was uncertainty that this represented clinical practice that was indeed different from others, there was more potential harm than benefit from publication.

It has been the responsibility of the specialist society (the SCTS) to inform surgeons and hospitals (including the medical director and chief executive) of outlier status. The SCTS engages with the audit providers and takes responsibility for notifying and advising individuals and institutions of any outlier status. In this regard, the most senior officers of the SCTS take on a pastoral role when informing surgeons. For these reasons, it is important to review the impact of this period of significant change in scrutiny and public reporting of cardiac surgery in the UK and Ireland on both surgical activity and risk-adjusted patient outcomes.

8.2 Methods

Currently, data on all NHS cardiac surgery in the UK are submitted to NICOR. NICOR is an independent organisation that is funded by NHS England through the Healthcare Quality Improvement Partnership[7] to provide six cardiovascular audits. Data are entered at source by clinicians, and individual hospital audit departments check data accuracy and formally sign off submissions. The data then go through a process of checking and cleaning at NICOR before revalidation by individual hospitals.

Risk adjustment for case mix is a key part of the process. As in-hospital mortality has fallen over time, the risk stratification calculation is recalibrated to reflect contemporary outcomes. Status at discharge (dead or alive) is the most critical data field and if this field is blank when the data are submitted to NICOR, then it is assumed that the patient died in hospital. Consequently, there is a strong incentive to complete this data field and completion is generally close to 100%.

Today, surgeon-specific data are published on risk-adjusted in-hospital survival for non-emergency cardiac surgery on the SCTS website. During the period reviewed in this Blue Book, data were published for a 3-year cycle (to allow a high enough case volume) for surgeons with at least 100 operations. Control limits were shown that identified individual surgeons and hospitals with risk-adjusted mortality that was three standard deviations (99.8%) better or worse than expected. Surgeons with mortality at two standard deviations (95%) were also notified but data at this statistical level, where the probability of a real difference from others was less certain, were never in the public domain. The former were referred to as alarms and the latter as alerts. There was also a correction for overdispersion, which was more important at surgeon level than at hospital level because of the larger cohort.

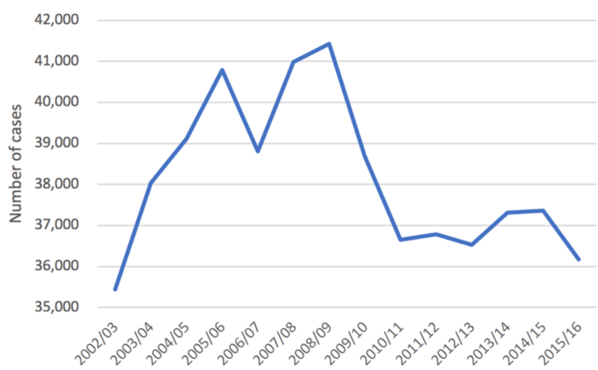
8.3 Results

8.3.1 Association between case volume and changes in outcomes publication

As described above, there has been evolution in outcomes reporting. Until 2005, individual surgeon outcomes data were not in the public domain. However, hospital outcomes were published in Blue Books and reported at the SCTS annual business meeting between 2002 and 2005. As the decision to operate is usually an individual one between patient and surgeon, one would not expect any influence until individual outcomes were published. This first occurred from 2005, initially for CABG and aortic valve replacement operations. From 2009, risk-adjusted in-hospital mortality was published for all cardiac surgery. In 2013, there was further public scrutiny and publicity with the advent of the Consultant Outcomes Publication initiative, championed by the Medical Director of the NHS.

Although there are many other influences affecting the volume of cardiac surgery performed in the UK, including the growth of alternative treatments (e.g. percutaneous coronary intervention instead of CABG), the temporary reduction in total procedures following 2005–2006 may be attributed to

Figure 45
Total number of adult cardiac surgery procedures recorded in NACSA



surgeons' concerns about outcomes reporting but this was already corrected by 2007–2008 with an increase in total caseload (Figure 45). The decline in case volume between 2008–2009 and 2011–2012 is mainly accounted for by the reduction in CABG surgery during this time. Despite the substantial changes in outcomes analysis, public reporting and scrutiny of surgeons over this period, it appears there is little evidence for any lasting influence on the volume of work performed. In a national health system where patients would not have access to referral outside the UK and where surgeons are paid by salary rather than fee for service, this is reassuring.

8.3.2 Evidence for risk-averse behaviour due to changes in outcomes publication

If there was any influence of risk-averse behaviour, it might be expected to be seen in a reduction in surgery for older patients and those with higher risk profiles. The key years of 2005, 2009 and 2014 (and the subsequent years) are still the most relevant. Looking at the mean age of all patients undergoing cardiac surgery, there is a steady increase from 2002 to 2016, and no effect from these key changes in analysis and publication strategy is visible (Figure 46). In addition, there is also a gradual and sustained increase in mean logistic EuroSCORE with no sudden annual changes (Figure 47). While one cannot claim that risk-averse behaviour does not exist in clinical practice, there is no evidence from the national audit that increased transparency from outcomes reporting has had any adverse effect on access to surgery for the oldest and sickest patients.

8.3.3 Change in risk-adjusted outcomes and the influence of public reporting

As is evident in Figure 47, the period 2002–2016 is associated with both a sustained increase in patient risk profile and a decrease in in-hospital mortality. It is this that is perhaps the greatest achievement of cardiac surgery in the UK and Ireland during this era; despite an aging population with more comorbidity referred for surgery, the survival of these patients has improved. Again, these changes are smooth over the years, without any dramatic annual influences visible. Figure 48 demonstrates that these improvements are consistent across CABG, valve and aortic surgery.

Whether these improvements are caused directly by the influence of audit, comparison

Figure 46

Mean age of all patients undergoing adult cardiac surgery

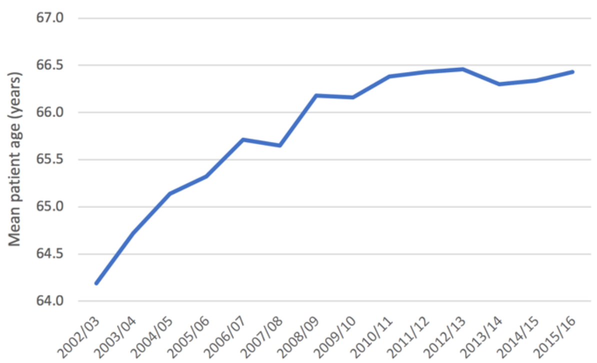
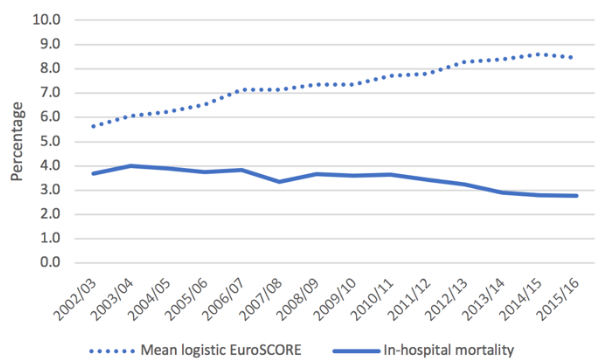


Figure 47

Mean logistic EuroSCORE and in-hospital mortality rates for adult cardiac surgery



of outcomes at hospital and surgeon level, great transparency or indeed public reporting itself is a different argument, and it is difficult to be certain when reviewing retrospective data. Although the sophistication of risk adjustment and the completeness of data collection are only available for the time period reviewed here, we can compare changes in crude mortality with historical controls in the UK and with other contemporaneous international datasets where individual surgeon data have not been reported in the public domain.

Data from the SCTS UK Cardiac Surgical Register are available for the years prior to 2000. During that period, there was also a reduction in mortality but it was much less dramatic. The average in-hospital mortality rate for isolated CABG surgery for 1977–1999 was 2.6% and for valve surgery, it was 5.5%. For all cardiac surgery (excluding congenital surgery, which at that time was reported in the same registry), the average in-hospital mortality rate was 5.2%. For the 15 years from 1984 to 1999, there was relatively little change: the CABG mortality rate reduced from 2.6% to 2.3% and the valve mortality rate from 5.3% to 5.2%.

The SWEDEHEART (Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies) registry[8] publishes detailed information on cardiac surgery in Sweden and makes comparisons between individual hospitals but has not published surgeon-level data. While there are important differences in the databases (with a smaller population in Sweden and SWEDEHEART reporting 30-day mortality rather than in-hospital mortality), the trends in mortality for CABG, valve and all cardiac surgery up to 2016 can be compared with those from the UK and Ireland (Figures 48 and 49). The improvements seen in Sweden are less pronounced than in the UK and Ireland during the period 2009–2016.

Figure 48
UK cardiac surgical register in-hospital mortality rates by procedure

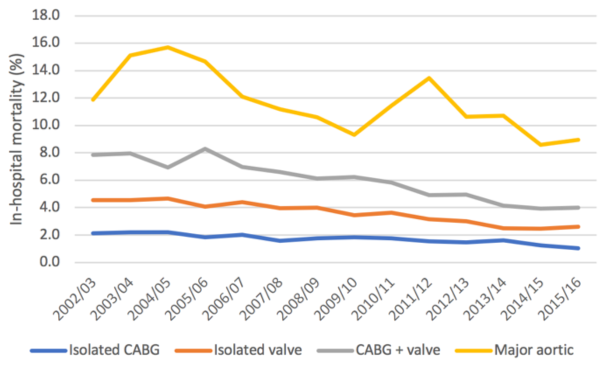
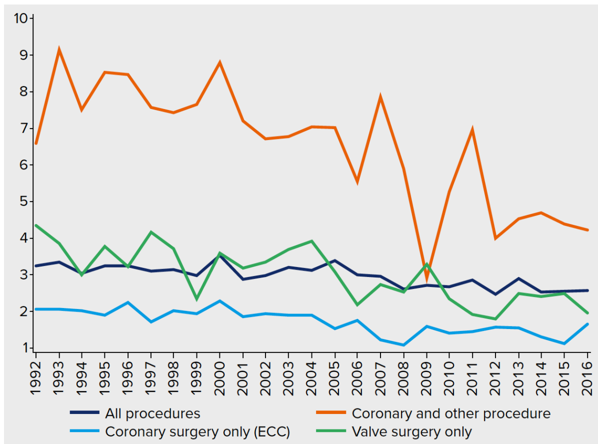


Figure 49
Swedish cardiac surgical register 30-day mortality rates by procedure



8.3.4 The influence of outcomes reporting on individual surgeons

Before the public reporting of outcomes data, the SCTS already had a well-established internal governance mechanism. Any surgeon with mortality that was two standard deviations above the national mean would be notified (along with his or her unit's audit lead) and a review of practice would be initiated.

Prior to more sophisticated risk adjustment, based on unadjusted mortality, most of these outliers were due to process or institutional case mix reasons. However, as the risk adjustment process became more refined and as the cases included changed from isolated indicator operations to encompass the whole of cardiac surgical practice, over a three-year period, the chances that a statistical outlier was indeed clinically important grew. Alongside these changes, the SCTS improved its governance mechanisms to support surgeons but it remains true that it is far easier to identify practice outside statistical control lines than to understand the reasons or initiate improvements. From 2005, detailed records exist and the effect on individual surgeons is reported here for the first time.

For the period 2005–2016, there were 55 alerts and 10 alarm notifications for surgeons. The number of participating consultant cardiac surgeons during this decade was in the range of 250 to 275. Among these surgeons, 21 of those who received alerts and 5 of those who received alarms stopped operating during this period. In three of these cases, this occurred at the start of the surgeon's career and it appears that it precipitated a change in career. In some cases, the notification occurred in the last few years of a career, near retirement, and was possibly explained by falling case volume and increasing case risk. It is not known whether the notification hastened retirement.

For 25 of these consultants, there was a single notification but 19 received two notifications and 14 received more than three; the maximum number received was five. As data were analysed for a rolling three-year cycle, once an alert or alarm was triggered, it could take more than a year to recover and so successive notifications were relatively common.

In each audit cycle, between five and ten surgeons received positive alert notifications that their practice was better than expected at the 95% control limit. There were no surgeons with a positive alarm in the period 2005–2016.

8.4 Discussion

Although publication of surgeon-specific data has been associated with improvement in risk-adjusted outcomes over time in the UK and Ireland, no causation has been proved. However, it has been shown in many fields that the mere act of collecting data, measuring performance and comparing outcomes improves these outcomes (the Hawthorn effect).

Looking at the rate of improvement, there is some evidence that this has been greatest during the recent era of outcomes publications. It is this improvement in risk-adjusted outcomes, despite increasing patient age and risk profiles, that is the real success of cardiac surgery in the UK and Ireland since 2000. It is reassuring to note that the national data do not indicate any negative influence from outcomes reporting at surgeon level. We do have to be aware that for the individual surgeon, an alert or alarm can have a devastating influence and for a specialty that relies on self-confidence, this cannot be underestimated. It is therefore reassuring that most surgeons who have received an alert or, indeed, an alarm have had their practice reviewed and continued working successfully.

Some surgeons have questioned the value of publicly reporting surgeon-specific survival. In a 2015 survey of European cardiac surgeons, over 90% felt that individual data should be collected but not published in the public domain while 69% felt that mortality (or survival) should only be reported by hospital.[9] The issues driving this debate have been reported in the *Bulletin* of the Royal College of Surgeons of England to inform other surgical specialties.[10,11] One of these is the accountability of the whole team delivering cardiac surgical care and that of the individual surgeon. The environment in which cardiac surgery is delivered today is very different from that during the time of the failings at the Bristol Royal Infirmary. Modern cardiac surgery is very much a team performance although some patient surveys indicate that they prefer to know about their individual surgeon rather than the hospital at which he or she works.

It is of course the individual surgeon who accepts the patient, decides on the operation, explains the risks and benefits to consent the patient, performs the operation and oversees the aftercare so if any one individual is more responsible than other team members, it is still the surgeon. Nevertheless, during the period of the experience reported here, many working practices have changed; there is much more shared responsibility for complex patient care and it is more of a team effort.

It was the public identification of individual consultant outliers that has perhaps been the most controversial aspect of the audit programmes.[12] However, the ability to identify statistical outliers is relatively easy compared with the governance needed to appropriately investigate and deal fairly with those identified. Reporting of surgeon-specific data involves a difficult role for a specialist society but it is usually this organisation that is best placed to deliver the governance around the data.[13] It is a careful balance to protect patients and be fair to the surgical profession. NHS England originally championed its Consultant Outcomes Publication initiative in 2013 (although the name was later subtly changed to Clinical Outcomes Publication) on its NHS Choices website. Subsequently, that website disappeared and there was more reliance on specialty-specific audit data from individual surgical society websites.

The SCTS believes that the benefits both to patients and to the profession in reporting outcomes make this process worthwhile, but it also recognises the importance of local governance at hospital level and that the process must evolve to remain appropriate to contemporary practice. It is hoped that now that the public and profession have assurance that cardiac surgical performance is actively monitored in the UK and Ireland, and they have a better understanding of the governance involved, actual publication of surgeon-specific survival data may become redundant in the future. It may be that publication of a more comprehensive package of multiple outcomes at hospital level is a better indicator to drive improvement in quality of care for adult cardiac surgery patients over the next 15 years.

References

1. Keogh BL, Dussek J, Watson D *et al*. Public confidence and cardiac surgical outcome. *BMJ* 1998; **316**: 1759–1760
2. National Institute for Cardiovascular Outcomes Research. About adult surgery. https://www.nicor.org.uk/national-cardiac-audit-programme/adult-cardiac-surgery (cited October 2020)
3. The Guardian. Heart surgery data: risk adjusted. https://www.theguardian.com/society/2005/mar/16/NHS (cited October 2020)

4. Roques F, Nashef SA, Michel P *et al*. Risk factors and outcome in European cardiac surgery: analysis of the EuroSCORE multinational database of 19030 patients. *Eur J Cardiothorac Surg* 1999; **15**: 816–823
5. Society for Cardiothoracic Surgery. Hospitals. https://scts.org/hospitals/ (cited October 2020)
6. Grant SW, Hickey GL, Dimarakis I *et al*. Performance of the EuroSCORE models in emergency cardiac surgery. *Circ Cardiovasc Qual Outcomes* 2013; **6**: 178–185
7. Healthcare Quality Improvement Partnership. About HQIP. https://www.hqip.org.uk/ (cited October 2020)
8. *SWEDEHEART Annual Report 2016*. Stockholm: Karolinska Institute; 2017
9. Jahangiri M, Bilkhu R, Borger M *et al*. The value of surgeon-specific outcome data: results of a questionnaire. *Eur J Cardiothorac Surg* 2016; **50**: 196–200
10. Westaby S, Baig K, Pepper J. Publishing SSMD: the risks outweigh the benefits. *Bull R Coll Surg Engl* 2015; **97**: 155–159
11. Bridgewater B. Patient-facing data is essential in the digital era. *Bull R Coll Surg Engl* 2015; **97**: 160–163
12. Marsh S. We don’t know who the safe surgeons are. *The Times* 25 April 2016
13. Ray S, Irvine D, Boseley S *et al*. *Maintaining Good Clinical Practice – Handling of Potential Consultant Outliers*. London: British Cardiovascular Society; 2015