A 15-year study of the changing demographics and infection risk in a new UK cardiac surgery unit†

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Abstract

OBJECTIVES: National trends in cardiac surgery show a shift towards a higher preoperative risk profile and factors that might also be expected to increase the risk of postoperative infective complications. We document the changing patient demographics in the first 15 years of a new cardiac surgery unit and examine the impact of these and other changes in estate, staffing and clinical protocols, on the risks of common postoperative infections.

METHODS: Data recorded included patient age, sex and body mass index, type and number of operations, logistic EuroSCORE, mortality rate, urgency of operation, reoperation rate, requirement for intra-aortic balloon pump, incidence of diabetes and the incidence of common postoperative infections.

RESULTS: A total of 8449 cardiac operations were undertaken. The mean patient age increased from 62.71 to 65.82 years; procedural complexity increased with the proportion of isolated coronary artery bypass procedures falling from 72.8 to 54%; there were increases in the urgency of operation (11.3–26.9%), average patient body mass index (27.01–28.67), the incidence of diabetes (12.3–21.2%), logistic EuroSCORE (5.36–7.74) and intra-aortic balloon pump usage (6.4–15.6%). The incidence of superficial sternal infection reduced (3.9–1.4%); other wound infection rates were low and showed no overall trend with time. Urinary tract infection varied between 0 and 1.7%, but did show a significant increase over the last 3 years (P < 0.01).

CONCLUSIONS: This study demonstrates a change in the patient profile, yet despite an increase in infection risk factors, no increase in actual infection rates. The importance of non-patient factors in influencing the outcomes after cardiac surgery is discussed.

Keywords: Database • Cardiac Surgery, Complications • Wound infection

INTRODUCTION

National demographics have changed in recent years, with the influence of a modern lifestyle impacting upon health statistics. Locally, there is a high level of social deprivation and a prevalence of cardiovascular disease that is 33% greater than the national average. Smoking, diabetes and obesity are all associated with social deprivation [1], and while these are cardiovascular risk factors, they are also risk factors for postoperative infection after cardiac surgery [2]. The latter carries a high economic burden and has a significantly negative impact upon patient recovery [3].

Cardiac surgery patients are at risk of developing wound infections, sepsicaemia and pneumonia. Urinary tract infection is the most common nosocomial infection and often occurs in critically ill patients and in cardiac surgery patients (who all receive urinary catheters), during the postoperative period [2, 4, 5].

Specific to coronary artery bypass surgery is the risk of saphenous vein harvest site infection, which can lead to skin necrosis and wound dehiscence [6] and can therefore have a considerable impact on patient mobility and overall speed of recovery.

One might expect that a cardiac surgery unit in a relatively deprived area of the UK would experience above-average levels of postoperative infection and that this trend would have increased with time, to mirror increasing risk factors. This article therefore aims to examine the epidemiological changes in a population of patients who have undergone cardiac surgery during the first 15 years of a newly opened regional unit and to see how changes in the patient profile, the estate of the hospital and evolution in clinical protocols have influenced postoperative infection rates.

MATERIALS AND METHODS

The adult cardiac surgery unit in Nottingham, UK opened in September 1995. Data from all operated patients were entered...
onto an externally validated database by a dedicated Audit Clerk and have been included in the study.

The origins of the hospital are Victorian and the buildings initially occupied by the cardiac surgery unit were over 100 years old. In December 2005, the service moved from a general theatre block, a shared ward and a small intensive care unit, to a purpose-designed and dedicated new building, which incorporated modern infection control requirements including an advanced ventilation system throughout the building and laminar airflow in the operating theatres.

Clinical protocols were updated with time but did not fundamentally alter. Antibiotic prophylaxis was always given for 24 h and followed local microbiological advice, aimed principally against gram positive cocci, using Cephuroxime or Flucloxacillin with Gentamicin. Preoperative shaving (performed within 24 h of operation), showering (with an antiseptic) and in-theatre skin preparation procedures (an alcoholic iodine solution) did not change over the study period. In May 2008, however, in line with UK National Health Service [7, 8] and local hospital infection control guidance, the unit policy to use chlorhexidine as a skin preparation prior to urinary catheterisation was changed and sterile saline was used instead. Diabetic management was meticulous, followed UK best practice guidelines and did not fundamentally change during the study period and vein and radial artery harvesting for coronary artery surgery was via the ‘open’ method.

Demographics studied included patient age, sex, body mass index (BMI), type and number of operations, logistic EuroSCORE, urgency of operation, incidence of postoperative death, re-exploration, intra-aortic balloon pump (IABP) usage and diabetes. Unless otherwise stated, statistical analysis of trends over time was based on comparison of data from the first 5 and last 5 years of the study.

In-hospital infections studied included deep and superficial sternal wound infections (diagnosed according to the criteria outlined by the Centre for Disease Control and Prevention) [9], culture-positive urinary tract infections and saphenous vein and radial artery harvest site infections.

RESULTS

Number of cases

In 15 years, 8449 operations were performed, with a steady increase in the number conducted annually; the current workload represents an increase of 236% over those performed in year 1.

Patient age

The proportion of older patients increased significantly ($P < 0.001$; ANOVA). Those over 75 years accounted for 6.4% of the total caseload in the first year, rising to over 20% currently; the percentage of patients over 80 years of age rose 10-fold from 0.7 to 7.3%. The average age of the patients was 62.71 years in year 1 and increased to 65.82 in year 15, with a peak of 67.32 in year 14.

Patient sex

The percentage of males varied from 67.6 in 1996/97 to 75.2% in 2007/08, generally increasing with time. The mean percentage of men in the first 5 years (69.9%) was statistically different from the mean of the last 5 years (73.9%) ($P < 0.01$; z-test).

Types of procedures

The complexity of the surgery required has increased. The proportion of isolated coronary artery bypass graft operations (CABG) decreased steadily from 72.8 in year 1 to 54% in year 15, with a corresponding upward trend in single valve replacements from 13.3 in year 1 to 20.9% in year 15 and a similar upward trend in combined CABG and valve replacements and other more complex and multiple procedures (Table 1).

<table>
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<th>Year</th>
<th>CABG</th>
<th>CABG + valve</th>
<th>CABG + valve + other</th>
<th>CABG + other</th>
<th>Valve only</th>
<th>Valve + other</th>
<th>Other</th>
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<td>11.2</td>
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<td>2.8</td>
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Values shown are a percentage of the total number of procedures conducted per year.
Urgency of surgery

‘Urgent’ (or non-elective) procedures are defined as those that are required to be performed during the patient’s presenting admission. Our data showed that the percentage of urgent procedures increased significantly over 15 years ($P = 0.002$; $z$-test), from 11.3 in year 1 to 26.9% in year 15.

Diabetes

The percentage of diabetic patients undergoing cardiac surgery increased significantly ($P < 0.001$; $z$-test) from 12.3 in year 1 to 21.2% currently. Initially, this increase was accounted for by those diabetic patients managed by oral or diet control (1999–2004). However, since year 10 (2004/05), the increase in the number of diabetics was mainly in the insulin-controlled category.

Body mass index

The average BMI increased over the 15-year period from 27.01 in year 1 to 28.67 kg/m$^2$ in year 15, but did not rise significantly ($P = 0.16$; $z$-test).

Logistic EuroSCORE

The average logistic EuroSCORE per annum showed a gradual, but significant upward trend over the 15-year period ($P < 0.001$; $z$-test), from 5.36 to 7.74.

Intra-aortic balloon pump

The percentage of patients receiving an IABP increased significantly ($P = 0.001$; $z$-test), from 6.4 in year 1 to 15.6% in year 15.

Patient deaths

The overall death rate in the unit remained relatively steady over the 15-year period, at around 3–5%, despite the patient cohort being at greater predicted risk of death.

Reoperation rates

Overall, the incidence of reoperation for bleeding in the initial hours or first few days after primary surgery has been low, averaging 2.8% over the 15-year period studied; there were fluctuations, but no overall trends with time. There was, however, a difference in the overall reopening rate between elective and non-elective (urgent) cases, with reopening being more likely in non-elective cases ($P = 0.037$; $t$-test). We observed particularly high rates of reopening in non-elective cases in 2004/05 and 2005/06.

Infection rates

We looked at five different types of in-hospital, postoperative infection as described above. Unless stated, no changes reached statistical significance. The pathogens and resistance patterns of pathogens varied over the study period, but changes were sporadic and did not show trends with time.

Superficial sternum. The incidence of superficial sternal wound infection decreased over the 15-year period, from 3.9 in year 1 to 1.4% in year 15, with a range of 1.1–6.7%. There was, however, a peak incidence of 6.5 and 6.7% between 1997 and 1999.

Deep sternum. The incidence of deep sternal wound infection fluctuated within a range of 0.1–1.2% and showed no overall trends.

Radial artery harvest site. The range of radial artery harvest site infection was 0–1.7%, with a modal value of 0%. There was an isolated peak in incidence between 2005 and 2007, when the incidence of infection rose to 1.6 and 1.7%. These years were the only occasions when the percentage exceeded 1%.

Long saphenous vein harvest site. The incidence of infection ranged from 0.4 to 10.1%. There was no overall trend and values fluctuated yearly. The peak incidence of 10.1% (1998/99) was almost double the second greatest yearly incidence of 5.8% (1997/98). In the majority of years, the incidence of infection was below 3%.

Urinary tract infection. There was no overall trend, and the yearly incidence ranged between 0 and 1.7%. However, the last three consecutive years of the study showed consistently elevated rates of between 1.4 and 1.6%, giving a statistically significant average incidence, more than twice that of the average during the previous 12 years ($P < 0.01$; $z$-test).

Urgency of operation. Although the percentage of patients requiring non-elective surgery increased, the pattern and incidence of infection did not vary significantly between those undergoing elective operation and those undergoing non-elective operation ($t$-test).

Reoperation. The risk of reopening was increased in non-elective cases, but the risk of postoperative infection in those cases was not increased. Overall, however, the risk of developing both superficial and deep sternal infections was significantly increased after reopening (1.65–3.85% and 0.45–2.56%, respectively; $P < 0.01$; $z$-test).

DISCUSSION

Changes described nationally have been echoed in this study [10]. We have observed a trend towards a much older population with the mean age of patients increasing by more than 3 years over the 15-year period and the proportion of octogenarians rising 10-fold. Furthermore, the percentage of patients undergoing isolated coronary artery bypass surgery has fallen by a quarter, to be replaced by greater numbers of valve operations and complex multiple procedures.

The logistic EuroSCORE-predicted mortality increased by over 44% and the requirement for an IABP increased by 143% over 15 years. In addition, there has been an increase of 138% in the
proportion of patients requiring urgent rather than elective surgery. Despite all these factors, our overall mortality has remained reasonably constant (3% in the last 3 years). Moreover, not demonstrating a yearly increase in infection rates, in the face of increasing EuroSCORE and case complexity, would also suggest that the type of cardiac procedure, EuroSCORE and surgical risk had little effect on infection risk. Certainly, we have found that the requirement for an urgent operation made no difference.

While the factors described above might also be expected to influence the postoperative infection risk, two other variables of even more relevance have also changed [2, 11]. First, is the degree of obesity. A high BMI does not increase mortality [10], but is certainly associated with an increased risk of infection [12–14] and the mean BMI of our patients increased by over 6%. One in three adults in the world are defined as overweight (BMI > 25 kg/m²) and one in nine as obese (BMI > 30 kg/m²) [15]. Our patient’s average BMI increased from an already overweight definition, to a BMI of 28.67 kg/m².

Second, it is well known that the prevalence of diabetes has risen, with current estimates of 2.4 million people being affected in the UK, an increase from 1.4 million in 1996 (Diabetes in the UK 2010: Key statistics on Diabetes; http://www.diabetes.org.uk/Professionals/Publications-reports-and-resources/Reports-statistics-and-case-studies/Reports/Diabetes-in-the-UK-2010/). This upward trend is reflected in our own data as the percentage of diabetic patients undergoing cardiac surgery has grown from 12.3 in year 1 to 21.2% currently. Initially, this increase was accounted for by those diabetic patients managed by oral or diet control (1999–2004). However, since year 10 (2004/05), the increase in the number of diabetics was mainly in the insulin-controlled category, although this may reflect the changing trends in the therapeutic management of type two diabetes towards earlier intervention with insulin [16]. There is clear evidence that high glucose concentrations in the blood in the first 48 h after surgery are associated with an increased risk of deep wound infections [12].

Of the sites of infection examined, there was a decrease in the incidence of superficial sternal wound infection from 3.9 to 1.4% with an overall low rate, compared with other series (0.9 and 9%) [2, 17]. With regard to deep sternal infections, although we did not observe any trend with time, again the overall incidence was low (0.1–1.2% compared with typical values of 1–3%) [18]. Similarly, our reoperation rates (for bleeding etc.) were low: 2.8% overall, compared with a national average of 4.7% [10]. National statistics show an association between increasing age and the incidence of reoperation: 3.9% in those having all forms of cardiac surgery and aged <61 years, compared with 6.5% for those aged 81–85 years and 7.5% for those aged over 85 years. Despite the age of our patients increasing, our reopening rate has remained reasonably constant (3% in the last 3 years). Moreover, developing surgical skill and non-patient factors in determining infection risk.

Although we only documented in-hospital infections, saphenous vein and radial harvest site infection rates were again generally low: 0.4–10.1% for saphenous vein harvest site infection compared with typical rates in the literature of 2.4–15.4% (although generally around 11%) [19, 20] and 0.1–1.2% compared with typical rates of 2.1–3.1% for radial artery harvest site infections [20]. These rates were not affected by the urgency of operation as might have been expected.

Urinary tract infection is a particular risk after cardiac surgery as all patients are catheterized, but the risk is low. In our first 12 years, the incidence of postoperative urinary tract infection averaged 0.67%, and although it fluctuated, there was no clear trend. In contrast, we observed a doubling of the number of urinary tract infections in the last 3 years of the study (P < 0.01; t-test). In May 2008, a new Hospital protocol required a change in practice from chlorhexidine to saline skin preparation prior to catheterization. This was based on Department of Health guidelines, which stated that there was no evidence base for cleansing the urethral meatus with antiseptic preparations as opposed to sterile saline [7, 8]. Almost certainly this policy change has resulted in an over 2-fold increased incidence of urinary infection.

Lastly, prior to 2005, our unit in common with many hospitals in the UK, existed in old Victorian buildings with poor estate. In January 2005, we moved into a purpose-designed building with state-of-the-art infection-control parameters in place (controlled airflow throughout, laminar airflow in theatres, considerable space between patients and physical barriers and more streamlined patient flows). It might be expected that the risk of postoperative wound infection would decrease, but that was not observed in the last 5 years of the study, when, in fact, infection rates stayed constant. One might argue that the increase in infection risk factors in our patients, without state-of-the-art facilities infection risk would have risen, but there was no upward trend prior to the unit moving and so that argument would seem unlikely. It would therefore seem that the addition of laminar airflow in theatre and more modern infection control provision within the building have made no difference to our wound infection risk.

Our cardiac surgery unit is based in an area of the UK associated with above-average levels of social deprivation. Smoking, extremes of obesity and diabetes are all risk factors for cardiovascular disease and are all associated with social deprivation, but in addition, social deprivation itself is an independent predictor of increased risk of death after cardiac surgery [1, 21]. These factors are also predictors of risk in terms of postoperative infection and one might therefore expect an above-average incidence of wound infection in our unit. The changing profile of patients we have observed with time might also lead one to conclude that our postoperative infection rates would have increased, yet we have observed neither of these things and generally, our postoperative infection rates have been below average [2, 10, 20] and have not increased with time. These findings highlight the importance of non-patient factors (such as personnel, developing surgical skills, changing clinical protocols etc.) in influencing outcomes after cardiac surgery. We are a small team and are careful to standardize procedures and to ensure that junior staff follow our exacting protocols. High-quality surgical skills and meticulous attention to detail in all aspects of skin preparation, antibiotic prophylaxis and postoperative management have presumably
outweighed adverse patient factors to allow us to maintain a generally low infection risk.

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Conflict of interest: none declared.

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