Paediatric cardiac surgical mortality in England after Bristol: descriptive analysis of hospital episode statistics 1991-2002

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Abstract

Objective To describe trends in mortality of open cardiac surgery in children in Bristol and England since 1991.

Design Retrospective analysis of hospital episode statistics data.

Setting All open cardiac surgery of children in England.

Population Patients younger than 16 undergoing open cardiac surgical procedures in England between April 1991 and March 2002. Three time periods were defined: epoch 3 (April 1991 to March 1995), epoch 5 (April 1996 to March 1999), epoch 6 (April 1999 to March 2002).

Main outcome measure Mortality in hospital within 30 days of a cardiac procedure.

Results We identified 5221 open operations between April 1996 and March 2002 in children under 1 year and 6385 in children aged 1-15 years. Mortality for all centres combined fell from 12% in epoch 3 to 4% in epoch 6. Mortality in children under 1 year at Bristol fell from 29% (95% confidence interval 21% to 37%) in epoch 3 to 3% (1% to 6%) in epoch 6, below the national average. The reduction in mortality did not seem to be due to fewer high risk procedures or an increase in the numbers of low risk cases. Oxford had a significantly higher mortality than the national average in all three epochs (11% (5% to 18%) in epoch 6), which was not affected by adjusting for procedure or the inclusion of cases with missing outcomes.

Conclusions At Bristol, mortality for open operations in children aged under 1 year has fallen markedly, to below the national average. Nationwide mortality has also fallen. Improved quality of care may account for the drop in mortality, through new technologies or improved perioperative and postoperative care, or both.

Introduction

The Bristol inquiry found that mortality in Bristol was about twice as high as in other centres from April 1991 to March 1995, for open operations in children aged under 1 year.[1 2] We report data on the performance of Bristol Royal Infirmary and that of the other major centres in England since the original research.

Methods

We obtained hospital episode statistics (April 1991-March 2002) for open cardiac surgical procedures in children in England, including the 11 major centres. We defined two age groups: children aged under 1 year and children aged between 1 and 15. We used the same selection criteria, the same broad class of open procedures (requiring cardiopulmonary bypass), and the 11 procedure groups defined in an earlier report[3] to compare mortality in hospital within 30 days of a surgical procedure for each centre with the overall mortality for all centres combined.

In the original research, we defined "epochs": epoch 3 comprised April 1991 to March 1995. For comparison, we defined two further epochs: epoch 5 from April 1996 to March 1999; and epoch 6 from April 1999 to March 2002. We calculated mortality for each centre for each epoch. We used Bayesian simulation methods to calculate the probability that each centre is ranked worst.

We used binary logistic regression for mortality to calculate odds ratios relative to the overall mean. We used the 11 open procedure groups to adjust for procedure. To test the robustness of these analyses to data quality issues, we calculated the odds ratios, including all spells with a missing outcome, by coding them as discharged alive. We also looked at data by year.

Results

In epoch 3, we identified 3509 open cardiac operations in England in children under 1 year for the original study and 4741 such operations in children between 1 year and 15 years; we identified a further 5221 and 6385 operations, respectively, between April 1996 and March 2002. For epoch 3, 5.4% (190 cases) of open operations in children aged under 1 year were carried out in hospitals other than the 11 specialist centres. In epoch 6, this figure declined to 0.2% (five cases).

For children aged 1 to 15, the national mortality fell from 5% in epoch 3 to less than 2% in epoch 6. No centre in epoch 5 or 6 had significantly high mortality in this age group.

Figure 1 shows mortality for open operations for children under 1 year in three epochs for the 11 specialist centres in descending order, by total volume of cases. It shows Bristol with a mortality of 29% (21% to 37%, $P<0.001$) in epoch 3, but falling to 5% (2% to 9%, $P=0.798$) in epoch 5 and 3% (1% to 6%, $P=0.801$) in epoch 6. Mortality for all centres combined declined from 12% in epoch 3 to 7% in epoch 5 and 4% in epoch 6. Oxford had a significantly higher mortality than the national average in all three epochs: 19% (12% to 27%, $P=0.010$) in epoch 3, 14% (8% to 22%, $P=0.003$) in epoch 5, 11% (5% to 18%, $P=0.001$) in epoch 6. If Bristol is excluded from the first epoch, Oxford had the highest mortality for all three epochs. However, it too had a downward trend in mortality.

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BMJ 2004;329:825–7

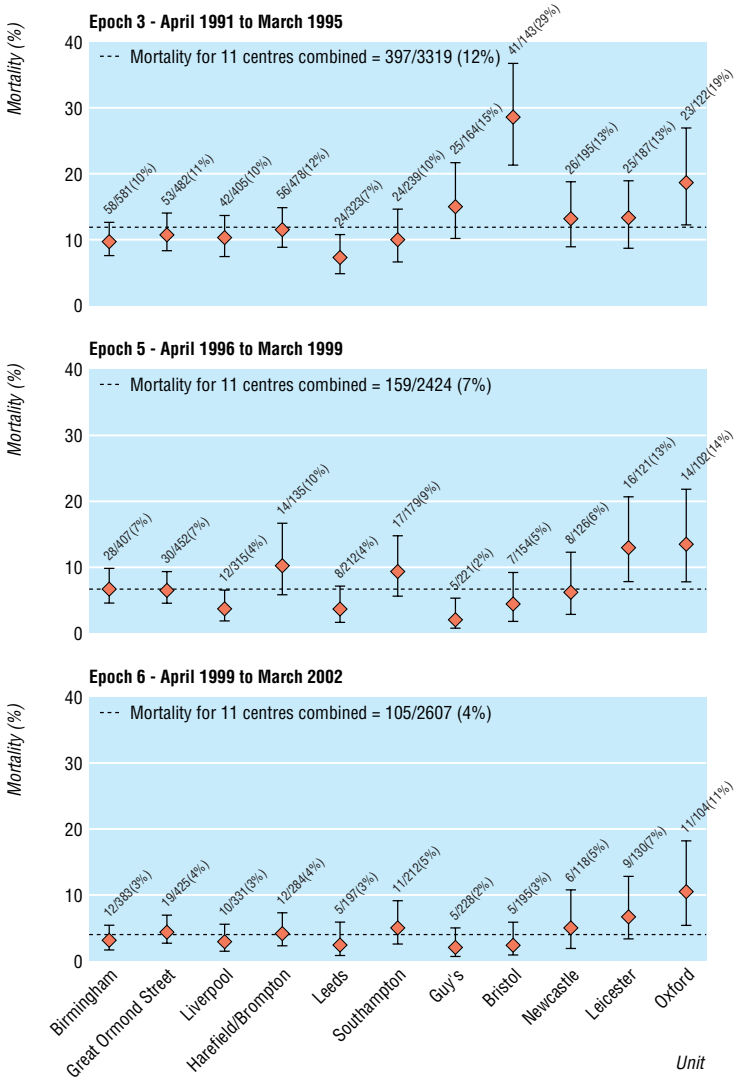

Fig 1 Mortality from open procedures in children aged under 1 year for 11 centres in three epochs; data derived from hospital episode statistics. Centres are listed by descending volumes of cases

The probability of at least one centre having a significantly high mortality in all three epochs by chance alone is less than 0.0002. The probability that Oxford had the highest mortality in epoch 3 was 3% (if Bristol is excluded it was 72%), 48% in epoch 5, and 79% in epoch 6 (see table A on bmj.com).

Adjustment for procedure by using the 11 open procedure groups made little difference to the pattern of mortality, with Oxford remaining as the only centre with a significantly high mortality over all three epochs (see table B on bmj.com). The only other centres that had a significantly high odds ratio after adjustment for procedure were Harefield-Brompton (odds ratio 2.04, 95 confidence interval 1.14 to 3.65, P = 0.016) in epoch 5 and Leicester (3.24, 1.88 to 3.95, P < 0.001) also in epoch 5 (see figure A on bmj.com).

The proportion of admissions with outcomes unknown decreased over time from 5.1% in epoch 3 to 1.4% in epoch 6. However, the proportion varied between centres. We carried out a sensitivity analysis to examine the effect of including admissions with a missing outcome, recoded as discharged alive (figure B on bmj.com). Oxford remained the only centre with a significantly high mortality in all three epochs, with an odds ratio of 1.80 (1.20 to 2.70, P = 0.004) in epoch 3, 2.25 (1.20 to 4.19, P = 0.011) in epoch 5, and 4.17 (2.14 to 8.13, P < 0.001) in epoch 6. The odds ratio for Harefield-Brompton dropped in epoch 5 to 1.03 (0.58 to 1.81, P = 0.928), indicating that their high mortality in this epoch may have been due to incomplete data.

Figure 2 shows annual mortality for Bristol and for all centres combined, together with total numbers of open operations in children under 1. Within all 11 centres, the total number of open operations per year for children under 1 varied between 732 in 1991-2 and 967 in 1996-7, with no obvious trend. In epoch 3, Bristol was carrying out an average of around 43 open operations per year on children under 1. This has now increased to 66 patients a year in epoch 6.

For Bristol, mortality declined rapidly from 1995. For all centres combined, mortality also fell, but this seems to be a continuous trend throughout the entire period, which is significant (P < 0.01). The small peak in 1995 coincided with some missing data on outcomes ; if missing outcomes are reclassified as "alive when discharged," the peak disappears.

The 11 procedure groups all show a marked reduction in mortality (between 36% and 91%) between epoch 3 and epoch 6. The number of Fontan type procedures, procedures to correct tetralogy of Fallot and closure of ventricular septal defect, all increased. Numbers of procedures for total anomalous pulmonary venous drainage and mitral valve procedures remained about the same. There was a decrease in numbers for all other procedures examined (see bmj.com). When we adjusted for procedure for all units combined, mortality was still markedly higher in epoch 3 than in epoch 6, with an odds ratio of 3.5 (2.8 to 4.6).

Discussion

At Bristol, since the events that led to the inquiry[1] and after changes in the paediatric cardiac surgery service from 1995 onwards, mortality for open operations in

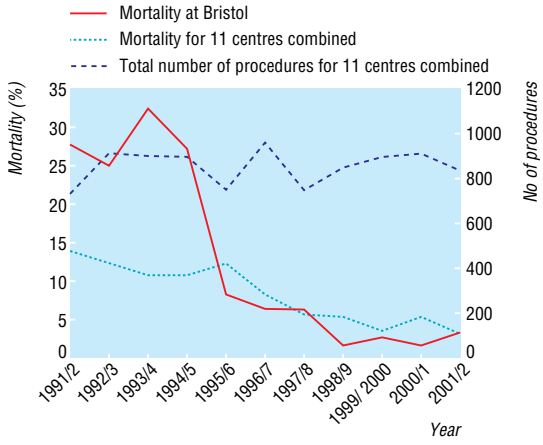

Fig 2 Mortality (based on admissions with known outcome) for and number of open operations on children aged under 1 year from April 1991 to April 2002 in 11 English centres; data derived from hospital episode statistics

children aged under 1 has fallen markedly, so that it is no longer an outlier. The national trend is towards a lower mortality as reflected in the Society of Cardiothoracic Surgeons of Great Britain and Ireland's own published figures.[4]

Data quality

Data quality is an important issue, although extensive comparisons with other data sources for the original research found that hospital episode statistics data are of sufficient quality to be used for these purposes. A recent paper also supports this.[5] Missing data on outcomes could, however, bias results. We examined the sensitivity of our analyses to include admissions where the outcome is unknown, and it makes little difference to the overall pattern of mortality. The same centres have a significantly high mortality in epoch 3 (Bristol and Oxford), epoch 5 (Oxford and Leicester), and epoch 6 (Oxford), even after adjustment for procedure. Our evidence also shows that the quality of data, at least in terms of completeness, is improving.

Possible change in procedures or cases

A reduction in the number of high risk procedures or cases, or an increase in low risk ones, might reduce mortality; but no indication exists that any such systematic shifts have occurred. The numbers of procedures that are now carried out may have changed due partly to increased antenatal diagnosis and termination of pregnancy, and partly to percutaneous intervention by cardiologists. We are not aware of any major changes in specific surgical technique except for hypoplastic left heart syndrome. Adjustment for procedure between epochs still shows a marked reduction in mortality over time.

Open procedures in England have shifted towards being carried out exclusively by the 11 specialist centres. Improvements in intensive care may also have contributed to the improvement in mortality.

Reasons for Oxford's death rates

Even after adjustment, Oxford remains the only centre with significantly raised mortality for all three epochs. The consistency of Oxford's high mortality relative to other units makes the problem of multiple comparisons less of an issue. There may be differences in case mix that we have been unable to adjust for. Some concern has been expressed over cardiac surgery at Oxford in the past.[6] The unit became aware in 1999-2000 of a possible downturn in their results for transpositions of the great arteries and stopped carrying out these from May 2000. The unit's own more recent data indicate that mortality has fallen since then (J Morris, medical director, Oxford Radcliffe Hospitals NHS Trust, personal communication, 2 April 2004).

The Oxford Radcliffe Hospitals NHS Trust contributes to the central cardiac audit database,[7] which collects more detailed information on case mix. An independent review of NHS paediatric and congenital cardiac services concluded that surgical results for all centres, based on only one year of data from the central cardiac audit database, all fall within a very narrow range and compare favourably with international results.[8] A recent paper, again based on the database,[9] found no detectable difference in 30 day or one year survival between any of the 13 UK tertiary centres for congenital heart disease; however, the analysis considered only one year of data, the centre comparisons were based on only six procedures, and no attempt was made to adjust for case mix. A reanalysis of our data for single years from 1991-2 to 1994-5 by using the same criteria indicates that the high mortality at Bristol would probably have been missed, reaching only borderline significance in one year, 1993-4 (11.7%, 99% confidence interval 4.7% to 22.7%) compared with a national average of 4.7% (3.3% to 6.3%).

What is already known on this topic

The Bristol inquiry between 1991 and 1995 showed that Bristol had a much higher mortality for open operations in children aged under 1 year than other major centres

What this study adds

Recent hospital episode statistics data show that in Bristol mortality has fallen markedly after the changes there

Nationally, a gradual fall in mortality has become evident from the time data were first available

Conclusion

Mortality at the Bristol Royal Infirmary has fallen markedly after the changes there, and a more gradual reduction in national mortality is evident from the time these data were first available. Improved quality of care may account for the decrease in mortality, through new technologies or improved perioperative and postoperative care, or both.

We thank Leslie Hamilton (consultant cardiac surgeon, Freeman Hospital, Newcastle upon Tyne) for his helpful comments on our draft and particularly for his advice on changing patterns of surgical and postoperative practice. We also thank Nicky Best (reader in statistics, Imperial College London) for her advice on statistical matters.

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Competing interests: The work was funded by Dr Foster Limited. BJ served on the panel for the Bristol Royal Infirmary inquiry. PA was an expert witness for the inquiry. PE was on the statistical review panel for the inquiry.

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(Accepted 4 August 2004)