RESEARCH REPORT

Elective surgery for aortic abdominal aneurysm: comparison of English outcomes with those elsewhere

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Introduction: The aim of this study was to quantify mortality after elective repair of abdominal aortic aneurysm (AAA) in England, and to compare English case fatality rates (CFRs) with those reported in the literature.

Patients and methods: English Hospital Episode Statistics (HES) for the financial years 1998/9 to 2001/2, linked to death data, were analysed. A systematic literature search was undertaken to identify studies reporting CFRs after elective AAA surgery. The CFR in England was compared with these studies by using confidence intervals on the CFRs and funnel plot techniques.

Results: In the English study, elective repair of AAA was performed on 11 338 patients of whom 771 died within 30 days after surgery (6.8%). The literature search found 66 studies: 34 reported mortality rates that were within the 99% confidence limits of the English rates, 31 below, and one study above.

Discussion: The CFR after elective surgical repair in England within 30 days of operation (6.8%) was higher than expected from the literature. Differences between England and other countries in quality of care is one possible explanation for the findings, but other explanations are possible and are discussed.

An abdominal aortic aneurysm (AAA) is a dilated and weakened segment of the abdominal aorta that occurs as a consequence of aortic medial degeneration. Its causes are not fully understood but risk factors for it include cigarette smoking, hypertension and raised cholesterol levels. AAA is much more common in men than in women and its incidence increases sharply with increasing age.^{1–2} The prevalence of AAA is around 5% in men over the age of 65 years.^{1–3} Patients with AAA are at risk of vascular rupture. Vascular rupture is a catastrophic clinical emergency and is usually fatal. As many as 50% of patients die without reaching hospital.^{2–4} Of those who are admitted to hospital, 25–50% do not undergo surgery and most of them die within hours or days.^{2–5} Peri-operative mortality after emergency open repair of a ruptured AAA is 40 to 50%.² Standard treatment for unruptured AAA with a diameter >5.5 cm is open surgical repair with the aim of preventing rupture.^{6–7} Despite advances in the peri-operative care of patients with AAA, the complication rate after elective surgery remains high. Peri-operative mortality after elective open repair is 3–5%.⁷ In contrast with other cardiovascular diseases where rates of hospital admission and deaths have fallen over recent decades,⁸ the rates for AAA have risen.² Accordingly, repair of abdominal aortic aneurysm (AAA) is an increasingly common surgical procedure. Because AAA surgery is common, and because of its high case fatality rate (CFR), CFRs after repair have been used for making comparisons between hospitals.^{9–10} Less work has been done, however, to compare case fatality rates between countries. An important potential use of routinely collected administrative data is that they may provide evidence for public health practitioners, policy makers and clinicians about whether outcomes are acceptably similar in different populations. Accordingly, the aim of this study was to report on CFRs after elective repair of AAA in England, using routinely collected data, and to compare them with rates elsewhere.

PATIENTS AND METHODS

Hospital Episode Statistics (HES) for the financial years 1998/9 to 2001/2, linked to data from death certificates processed by

the English Office for National Statistics, were analysed. HES include statistical information on all patients admitted to NHS hospitals in England (population 50 million). Linkage to data from death certificates meant that we were able to identify all postoperative deaths, regardless of when and where the patients died, rather than just identifying deaths in the hospital admission for AAA repair. We used information from the HES records to identify data about all patients who underwent surgical procedures for elective repair of AAA (for codes see Appendix 1). We calculated CFRs for these patients by taking all patients who underwent elective repair as the denominator, and deaths in these patients from any cause within 30 days after admission, regardless of place of death, as the numerator. Death rates for deaths in the same hospital admission as the operation, conventionally called “in-hospital” death rates, were calculated similarly. 99% confidence intervals were calculated on the rates. In addition, the effect of comorbidities on mortality was assessed using logistic regression.

A systematic MEDLINE search (from 1966 to October 2005) was undertaken using the following search terms: aortic aneurysm, abdominal; AND surgical procedures, elective; AND hospital mortality, OR mortality. The MEDLINE search was complemented by manual search of the articles' reference lists. Studies were excluded if there were fewer than 100 patients, if the number of patients was not specified, if the operations were specified as not having been elective, if the age group was restricted, or if there was a non-randomised comparison between different treatment modalities. Because of heterogeneity of the studies in data sources and design, no attempt was made to pool the data from the studies. Instead, we used a funnel plot technique to determine whether mortality reported in these studies was within the 99% confidence limits of the mortality rates found in the present study. An advantage of the funnel plot technique is that it loses less information than pooling, which can be an important

Abbreviations: AAA, aortic abdominal aneurysm; CFR, case fatality rate; HES, Hospital Episode Statistics; ICD, International Classification of Diseases

Figure 1 Funnel plot showing case fatality rates for elective repair of abdominal aortic aneurysm reported in the literature compared with the case fatality rate found in the current analysis and its 99% confidence limits. Information on each individual study is given in table 3.

Table 1 Characteristics of 11 338 patients with elective repair of abdominal aortic aneurysm in England: diseases as recorded on the patients' Hospital Episode Statistics record

	Number of patients (% of total)	Number of deaths (CFR)	OR (95% CI)
Diabetes mellitus	458 (4.0)	43 (9.4)	1.6 (1.1–2.1)
Coronary artery disease (chronic)	1188 (10.5)	178 (15.0)	2.9 (2.4–3.5)
Arterial hypertension	2857 (25.2)	194 (6.8)	1.0 (0.9–1.2)
Congestive heart failure	436 (3.8)	119 (27.3)	5.3 (4.2–6.7)
Renal failure (chronic)	408 (3.6)	112 (27.5)	5.7 (4.5–7.2)
Chronic obstructive pulmonary disease	863 (7.6)	82 (9.5)	1.4 (1.1–1.8)
Malignant diseases	310 (2.7)	23 (7.4)	1.1 (0.7–1.7)

Number of patients, and percentage of all patients, with each characteristic; number of deaths and 30-day case fatality rate (CFR, per 100 people) for patients with each characteristic; and age- and sex-adjusted odds ratio (OR) and its 95% confidence interval (95% CI) for deaths within 30 days after admission for patients with each characteristic.

advantage in comparing studies that are heterogeneous in design. This is because in funnel plots the results of each individual study remain apparent, whereas in pooling the findings from the individual studies are obscured.

RESULTS

As identified from HES, elective repair of AAA was performed in 11 338 patients with a mean age of 71.9 (standard deviation 7.0). Of these, 771 died within 30 days after surgery (6.8%; 95% CI 6.3 to 7.3) and 815 died in the hospital admission for surgery at any time interval (7.2%; 95% CI 6.7 to 7.7). Table 1 shows the comorbidities ascertained from HES records, the percentage of patients with each comorbidity, and the CFR in patients with each comorbidity. Of all patients, 1634 (14.4%) were women and, of these, 134 (8.8%) died within 30 days of operation. The CFRs for men and women in different age groups are given in table 2. Except in the oldest age groups, CFRs were higher for women than men. Overall, the age-adjusted odds ratio for 30-day mortality in women compared with men was 1.2 (95% CI 1.0 to 1.5; $p = 0.049$).

Sixty eight studies were found by the literature search strategy. Of these, 38 had to be excluded: 12 because they included thoracic, thoraco-abdominal or suprarenal aortic

aneurysms, and 11 because they reported on ruptured/non-elective/symptomatic AAA, three because they were non-randomised studies that included endovascular AAA repair, four because of restriction of age or other selection criteria, three because of small numbers, two because of double

Table 2 Case fatality rates (CFR) following elective repair of abdominal aortic aneurysm in England per 100 people within 30 days of admission

Age (years)	Men			Women		
	People	Deaths	CFR	People	Deaths	CFR
<60	525	11	2.1	35	1	2.9
60–64	1007	25	2.5	88	8	9.1
65–69	1979	91	4.6	233	15	6.4
70–74	2662	174	6.5	440	31	7.0
75–79	2433	195	8.0	554	52	9.4
80–85	911	104	11.4	236	29	12.3
>85	187	28	15.0	48	7	14.6
All age groups	9704	628	6.5	1634	143	8.8

Table 3 Study characteristics and case fatality rates (CFR) in the studies used for the funnel plot (fig 1)

Ref	First author, year	Study period	Country	Type of study*	Mean age†	Women (%)	Number of procedures	Def of CFR	CFR (%)
11	Dryjski, 1994	1987-91	USA	SC	68	0	111	H	5.4
12	Chang, 1987	1973-77	USA	SC	68	NS	120	H	9.2
13	Cheng, 2003	1999-00	Hong Kong	MC	71	28	128	H	10.2
14	de Carvalho, 2003	1994-00	Brasil	SC	67	12	130	H	3.1
15	Roger, 1989	1971-87	USA	SC	NS	21	131	30	4.6
16	Sicard, 1995	1990-93	USA	RCT	NS	27	145	H	1.4
17	Forbes, 2005	1998-03	Canada	SC	71	11	138	30/H	3.6
18	Williamson, 2001	1990-97	USA	SC	69	27	139	NS	4.0
19	Callaghan, 2005	1998-02	UK	SC	72	12	178	H	1.7
20	Batt, 1999	1987-91	France	SC	70	6	187	NS	5.9
21	Matsushita, 1997	1980-92	Japan	SC	NS	NS	189	H	3.2
22	Hertzer, 1987	1978-82	USA	SC	NS	NS	209	NS	4.4
23	Fielding, 1981	1960-79	UK	SC	68	14	222	30	6.3
24	Igari, 2001	1990-98	Japan	SC	71	19	228	H	3.1
25	Haug, 1996	1983-93	Norway	SC	70	19	246	30	4.1
26	Kruger, 2002	1995-00	Australia	SC	76	12	251	NS	5.2
27	Elkouri, 2004	1999-01	USA	SC	73	NS	261	30	1.1
28	Irvine, 2000	1991-98	UK	MC	70	0	276	H	7.0
29	Rosenthal, 2005	1990-00	Switzerland	SC	68	9	280	H	2.5
30	Nesi, 2004	2000-02	Italy	SC	71	6	286	H	3.2
31	Akkersdijk, 1998	1993-95	Netherlands	MC	69	10	291	H	4.1
32	Aune, 1995	1974-93	Norway	SC	68	10	327	30	5.2
33	AbuRahama, 1991	1983-87	USA	MC	69	23	332	H	3.6
34	Kertai, 2003	1991-99	Netherlands	SC	69	15	361	30	6.7
35	McCabe, 1981	1972-77	USA	SC	66	15	364	H	2.5
36	Mukai, 2002	1974-00	Japan	SC	70	19	392	H	3.8
37	Sakalihasan, 2005	1998-03	Belgium	SC	NS	NS	397	30	2.7
38	Ashton, 2002	1997-99	UK	RCT	NS	0	414	30	6.0
39	Diehl, 1983	1974-78	USA	SC	NS	NS	432	H	4.2
40	Forbes, 2005	2000-03	Canada	SC	72	16	463	30	4.5
41	Becquemin, 2000	1986-97	France	SC	69	7	470	30	5.3
42	Reigel, 1987	1980-85	USA	SC	76	17	499	NS	2.8
43	Golden, 1990	1973-89	USA	SC	69	NS	500	30	1.6
44	Stenbaek, 2004	1981-00	Sweden	SC	70	18	517	30	6.6
45	Cappeller, 1998	1978-87	Germany	SC	67	11	545	H	6.4
46	Menare, 2003	1990-00	USA	SC	71	18	572	H	1.0
47	Starr, 1996	1983-88	USA	SC	68	16	582	H	5.0
48	D'Angelo, 1993	1966-90	Italy	SC	NS	9	590	H	4.6
49	Berridge, 1995	1988-92	UK	MC	68	23	662	30	8.9
50	Johnston, 1994	1986	Canada	MC	69	20	679	H	4.6
51	Bradbury, 1998	1976-96	UK	SC	70	18	686	30/H	6.0
52	Bayly, 2001	1999	UK	MC	70	20	814	NS	6.4
53	Koskas, 1997	1989	France	MC	68	7.1	834	H	4.8
54	UK Small Aneurysm Trial, 1998	1991-95	UK	RCT	NS	17	838	30	6.6
55	Crawford, 1981	1955-80	USA	SC	66	14	860	30	4.8
56	Kantonen, 1997	1991-94	Finland	MC	NS	NS	929	30	5.1
57	Semmens, 1998	1985-94	Australia	AD	71	15	935	30	4.3
58	Lloyd, 1996	1979-94	USA	SC	70	23	1000	H	2.4
59	Axelrod, 2001	1997-98	USA	MC	70	0.5	1001	H	3.7
60	Haug, 2005	2000-01	Norway	MC	NS	NS	1019	H	4.8
61	Hertzer, 2002	1989-98	USA	SC	70	13	1135	30	1.2
62	Godet, 2005	1996-02	France	SC	67	10	1138	30/H	4.2
63	Collins, 2001	1991-93	USA	MC	68	NS	2268	H	3.4
64	Dardik, 1999	1990-95	USA	AD	70	22	2335	H	3.5
65	Hannan, 1992	1985-87	USA	AD	70	21.8	3570	H	7.7
66	Dimick, 2003	1997	USA	AD	72	21	3912	H	4.2
67	Lee, 2004	2001	USA	AD	72	22	4607	H	3.8
68	Wen, 1996	1988-92	Canada	AD	NS	16	5492	H	3.8
69	Kazmers, 2001	1991-95	USA	AD	NS	NS	5833	30/H	4.5
70	Dimick, 2002	1996-97	USA	AD	72	20	7980	H	3.4
71	Sollano, 1999	1990-95	USA	AD	NS	NS	9847	H	5.5
72	Pearce, 1999	1992-96	USA	AD	72	19	13,415	H	5.7
73	Dueck, 2004	1992-01	Canada	AD	71	18	13,701	30	4.5
74	Lawrence, 1999	1994	USA	AD	69	20	32,389	H	8.4
75	Birkmeyer, 2002	1994-99	USA	AD	NS	NS	140,577	30	5.7
	Heller, 2000	1979-97	USA	AD	69	15	358,521	H	5.6

Def, definition; CFR, case fatality rate: 30, deaths occurring within 30 days; H, deaths occurring during the index hospitalisation; 30/H: deaths occurring within 30 days or during the index hospital; NS, not specified.

*Types of study: AD, studies based on routinely collected administrative data; MC, multicentre case series studies; RCT, randomised controlled trials; SC, single centre case series studies.

†Mean age at operation.

publication of the data and three manuscripts because they were reviews or editorials. A further 36 studies were found by manual search of reference lists. We compare the results from our analysis with the results from these 66 studies in the figure. The horizontal line, at 6.8%, represents the CFR in our study. The funnel shows the 99% confidence intervals that would be found around the value of 6.8% in studies of different numbers of patients. The funnel narrows as the size of studies increases, because the increased size confers greater statistical power and therefore tighter confidence intervals. The values of the CFRs in the literature (table 3) are given on the funnel plot, with their place on the horizontal axis plotted according to the size of the study.

Thirty four studies reported mortality rates that were within the 99% confidence limits of our study of English rates; 31 studies were below; and one study⁷³ was above the 99% confidence limits (fig 1).

DISCUSSION

Current CFRs in England are higher than those reported in the literature. Potential reasons for this finding include differences between studies in definition or coding of an elective operation, differences in methods used to identify deaths (for example, whether systematic tracing of deaths after transfer or discharge was used), differences between studies in clinical case mix, or a real higher CFR in England than elsewhere. Patients with symptomatic AAA may be admitted for an elective but urgent operation. If such patients are typically recorded as having undergone elective procedures in English hospital statistical systems, but as urgent admissions in other studies, this could explain higher mortality rates in the English data. In our study the 30-day CFR (6.8%) and in-hospital mortality rate (7.2%) were very similar. However, if there are substantial differences between studies in whether patients are discharged home or transferred to other hospitals shortly after the surgical intervention, studies that report only in-hospital mortality could underestimate true peri-operative mortality.⁷⁶ Most of the studies in the literature use the 9th or the 10th Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-9 or ICD-10) for the classification of diagnoses. However, there are differences in the systems used for coding surgical operations: only English data are based on the 4th Revision of "The Classification of Operations" published by the Office of Population Census and Surveys whereas most of the others studies used the ICD-9 Procedural

Codes. This is particularly so for studies from the US.⁷⁵ Other differences between studies in case-mix cannot be ruled out because the information available to us for our study is fairly limited (table 1) and because information about comorbidity is not consistently recorded in the studies in the literature (table 3). However, age is known to be strongly associated with mortality⁶⁹ and age did not vary substantially between the present study and that in other publications (table 3). Some countries have recently started population-based screening programmes. This could result in detection of AAA at an earlier stage and, accordingly, this could result in variation between them in the size of treated aneurysms or in timing of surgery. Because the CFR after AAA repair depends on size of AAA, as well as comorbidities and age, this could be another reason for the observed differences in CFR between England and elsewhere. However, many of the data in the published studies were collected before the implementation of screening programmes.

It could be argued that our study is based on routinely collected statistical systems whereas some of the other studies in the literature are based on data specifically collected for the purpose of studying AAA. Publication bias is probably more likely with small studies from single specialist centres (in the present context, one would have to argue that it favoured the submission and publication of studies with particularly low CFRs) than in studies based on routine information systems in whole populations. Thirteen of the studies in the literature are based on data from routine information systems. These systems, like HES, represent an unselected and virtually entire population of patients in a whole geographical region. Our conclusion is unaltered by considering their results alone: CFRs reported by all but three of them are significantly lower than those for England.

The last reason for the observed differences in CFRs is that postoperative mortality may truly be higher in England than that reported in the studies from elsewhere. Even if there is no publication bias in respect of smaller studies, it could be argued that we have compared a national average CFR with centres that may have special interests and expertise in AAA surgery; and that English national rates might be expected to be higher than those in specialist centres elsewhere. Against this, it could be reasoned that national average rates should not differ from those attained in specialist centres; and that, if they do, there may be lessons to learn about how to improve national rates. We suggest that there is a case for a study of standards of care for AAA in England, compared with elsewhere, using access to detailed clinical information (including pre-existing comorbidities and postoperative morbidity) beyond that available from current routine hospital statistics.

MF and MJG designed the study. LG built the national linked files. MF analysed the data, and reviewed the literature. MF, MJG and LG wrote the paper. MF and MJG are the guarantors.

What is already known

- Compared with most other elective surgical procedures, death rates after elective surgical repair of abdominal aortic aneurysm are high.
- Death rates following such surgery have been used to make comparisons between hospitals.

What this paper adds

- The case fatality rate after elective surgical repair in England within 30 days of operation was 6.8%.
- This is higher than expected from the international literature.
- Differences between England and other countries in quality of care is one possible explanation for the findings, but other explanations are possible.

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Competing interests: None.

Ethical approval: Approval for analysis of the database has been obtained from the Central and South Bristol Research Ethics Committee in its role as a Multi-Centre Research Ethics Committee (04/G2006/176).

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APPENDIX: CODING

Only hospital admissions that were specified as elective, booked or planned were included.

The following diagnostic codes were analysed: I71.4 “Abdominal aneurysm, without mention of a rupture”; I71.9 “Aortic aneurysm of unspecified side, without mention of a rupture” (World Health Organization. International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10). Geneva: World Health Organization, 1992).

The following operation codes were analysed: L19.3-6, L19.8-9, L 21.3-6, L21.8-9 L23.1-3, L25 (Office of Population Census and Surveys. The Classification of Operations”, 4th Revision. London: Office of Population Census and Surveys, 1990).

SPEAKER'S CORNER

Childhood obesity: every little bit helps

Overweight and obesity can be simply viewed as a result of the equilibrium between energy intake and expenditure or widely viewed as a public health issue. For a better understanding of the obesity pandemic, the ecological model should be taken into account in the broad sense of the term, including mediator factors, such as education and behaviour changes, and also globalisation as an important determinant of overweight.¹ Childhood and adolescence are critical periods for the development of obesity. Overweight and prevalence of obesity are increasing mainly in children from low socioeconomic strata. The effect of environmental factors, such as social class, family structure and gender, in developing overweight, is not fully established even in adolescents. However, adolescents from low social classes already have a high risk of developing overweight, maternal education and maternal obesity being important associated factors.²

To prevent social inequalities in distribution of obesity, interventions should be carried out by improving maternal education. Even nowadays, there is still a lack of opportunities for women to obtain high educational levels. This is important because of the risk for their children and adolescents to become overweight, and also because among adult women, high overweight rates tend to be associated with low education levels. Moreover, political and social measures should also be planned to promote the sharing of parenting charges within the family (father, mother or others). Identifying paternal and maternal obesity seems to be useful in order to detect risk

groups for developing prevention programmes. The target population of prevention programmes to decrease obesity in children and adolescents should be children and adolescents, as well as their parents. In future, in order to reduce the increasing rates of overweight in adolescents, prevention programmes should be based on an integrated paradigm dealing together with parents and adolescents, and taking into account gender-related risk factors. Preventing obesity is a challenge for the control of other nutrition-related diseases in adult life, such as type 2 diabetes and cardiovascular diseases. Social and political interventions are also needed to reduce health inequalities.

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