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Mortality from Ruptured Abdominal Aortic Aneurysms: Clinical Lessons from a Comparison of Outcomes in England and the USA.

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ABSTRACT

Background

The fate of patients with ruptured abdominal aortic aneurysm (rAAA) has been shown to vary by country. More detailed study to compare practice might reveal the source of variation, and allow the formulation of pathways to improve care. This study compared in-hospital mortality for rAAA in England and the USA.

Methods

The English Hospital Episode Statistics and the USA Nationwide Inpatient Sample were compared for patients hospitalized with rAAA from 2005 to 2010. In-hospital mortality and the rate of non-corrective (conservative/palliative) treatment were analyzed by binary logistic regression for each healthcare system, after adjustment for age, gender, year, and Charlson co-morbidity index.

Results

The study included 11,986 patients with rAAA in England, and 23,838 rAAA in the USA. In-hospital mortality was greater in England (65·90% vs 53·05%, p<0·001). Intervention (open or endovascular repair) was offered to a greater proportion of cases (80·43% vs 58·45%, p<0·001) and endovascular repair (rEVAR) was more common (20·87% vs 8·54%, p<0·001) in the USA. These observations persisted in age/gender-matched comparison. In both countries, lower mortality was associated with rEVAR, greater hospital caseload (volume) for rAAA, hospital bed capacity and teaching status, and admission on a weekday.

Conclusion

In-hospital survival from rAAA, intervention rates and the uptake of rEVAR are lower in England than the USA. In both England and the USA, the lowest mortality for rAAA was seen in teaching hospitals with larger bed-capacity performing a greater proportion of cases with endovascular repair. These common factors suggest strategies for improving outcomes for patients with rAAA.

INTRODUCTION

The rupture of an abdominal aortic aneurysm (rAAA) is frequently fatal and accounts for the death of at least 45 individuals per 100,000 population.[1] Surgical intervention remains associated with high mortality despite evidence of improvement in published outcomes over recent decades.[2] In both the USA and England, there is evidence of inter-hospital variation in the mortality of patients admitted with rAAA. The fate of patients with AAA has also been shown to vary between countries, with differing outcomes published for a range of healthcare systems including the USA, UK, Western Europe and Australia.[3–5]

Modifiable technical, organisational or hospital-related factors play an important role in patient care, and merit further study in order to optimise service delivery and improve patient outcomes. A detailed study to compare international outcomes for rAAA would place data from an individual healthcare system in a broader context, and might allow the identification of factors that influence survival or the formulation of pathways to improve care.

The present study reported the outcomes of patients with rAAA in England and the USA, with comparison of in-hospital mortality, the proportion of patients managed by non-corrective treatment (i.e. conservative or palliative care), and the availability of endovascular surgery.

METHODS

Demographic and in-hospital outcome data were extracted from Hospital Episode Statistics (HES) and the Nationwide Inpatient Sample (NIS) for all patients diagnosed with rAAA between 1 January 2005 and 31 December 2010. The HES are the administrative data set for the English National Health Service (NHS) and contain information regarding every admission of a patient to hospital. The Nationwide Inpatient Sample (NIS) from the Healthcare Cost and Utilization Project (HCUP) is an anonymised, stratified sample of 20% of all discharges from USA hospitals, and represents the largest all-payer database of hospital admissions for USA healthcare.

The inclusion criteria comprised patients with a diagnosed rAAA, defined by International Classification of Diseases-10 (ICD-10) codes in HES and ICD9-CM codes in NIS data, as listed in the online appendix. Endovascular (rEVAR) and Open (OR) rAAA repairs were identified according to previously published methodology for the HES, and as listed in the online appendix for the NIS.[4,6–8] The primary outcome measures were in-hospital mortality, operative mortality and the decision to follow non-corrective (conservative/palliative) treatment for rAAA. Non-corrective treatment was defined by the patient having a diagnostic code for rAAA but no procedural code for surgical or endovascular rAAA repair. Secondary outcome measures included the proportion of operated cases managed by rEVAR, length of stay, discharge destination, and the proportion of cases managed in teaching hospitals or hospitals of varying bed-capacity.

Patient-level and hospital-level factors were extracted to enable comparable risk-adjustment in both HES and NIS data. These included age, gender, hospital and, year of admission. Pre-existing co-morbidity was defined separately for the USA and England with techniques validated independently for each country: using the Charlson Index for the NIS[9] and the Royal College of Surgeon's modified Charlson Index for HES.[10] Due to systematic differences in coding policies between the USA and England, risk adjustment for comorbidity was only used for within-country analysis rather than for comparative analysis between countries. Hospital factors included bed capacity, teaching status and, institutional annual volume (caseload) for rAAA. Hospital teaching status and bed capacity were defined according to standard NIS documentation, and classified for English hospitals from publicly-available data according to previously defined methodology.[11,12] Institutional volume (caseload) for rAAA was represented using quintiles according to previously defined methodology.[12]

Statistical analysis

All analyses were performed using SAS version 9·3 (SAS Institute, Cary, NC, USA) and STATA version 12·0 (Statacorp LP, Statacorp, Texas, USA).

Primary and secondary outcomes were modelled separately for HES and NIS data, using binary logistic regression with risk-adjustment for age, gender, social deprivation and co-morbidity index. Stepwise selection procedures were used with comparison of models by Akaike's Information Criterion (AIC) to ascertain whether individual covariates improved goodness-of-fit for prediction of in-hospital mortality and non-corrective treatment. Covariates considered for modelling included age, gender, social deprivation, comorbidity index, institutional procedural volume (caseload), institutional bed capacity and teaching status, geographical region and year of surgery, inter-hospital transfer status, and admission on a weekend versus a weekday. Inclusion in the model required a significance level of $\alpha = 0{\cdot}1$, and significant results were reported at $\alpha=0{\cdot}05$.

Age and gender-matched analyses were constructed to compare English and USA outcomes for in-hospital mortality and the decision to offer non-corrective treatment. HES and NIS datasets were linked using common variables defined above, and strata were created after matching patients for gender and 5-year age groups. Person-level matching was performed within each strata, allowing patients of equivalent gender and 5-year age group to be paired. Matched person-level comparisons of in-hospital mortality and the rate of non-corrective (conservative/palliative) treatment were performed between English and USA patients using McNemar's test for statistical significance.

Funding and Authorship

All authors had access to the study data throughout. Funding from the Circulation Foundation and the National Institute for Health Research (NIHR) supported the academic salary of authors AK and PJH but the funding bodies had no direct input into the content or interpretation of the present study.

RESULTS

11,799 patients in England and 23,838 patients in the USA were admitted to hospital with a rAAA during the study period. In England the mean (sd) age was 78·2 (8·0) years and 73·7% were male. In the USA, the mean (sd) age was 76·6 (9·6) years and 71·4% of patients were male. Full demographic details of patient characteristics are provided in the Supplementary Appendix.

In Hospital Mortality, Non-Corrective Treatment and Use of Endovascular Repair

In-hospital mortality was greater in England than the USA (65·90% vs 53·05%, p<0·001) [Table 1]. Intervention (rEVAR or open surgery) was offered to a greater proportion of cases in the USA (80·43% vs 58·56%, p<0·001) and endovascular repair was more common in the USA (20·87% vs 8·54%, p<0.001). Amongst patients who underwent intervention, mortality was similar in both countries (41·77% vs 41·65%, p=0·876). Mortality from endovascular repair was consistently lower than for open surgery, but comparative mortality following rEVAR was lower in the USA than England (26·84% vs 31·58%, p=0·018). A comparison of matched strata between England and the USA demonstrated that in patients of equivalent age and gender, overall in-hospital mortality and the rate of non-corrective treatment were significantly lower in the USA than England (p<0·001, Figure 1 and Figure 2).

Length of Stay, Discharge Destination and Teaching Hospital Status

The median length of stay of survivors of rAAA was longer in England (10·6 vs 16 days, p<0·001). English patients were more commonly discharged to their usual place of residence (79·99% vs 33·70%, p<0·001) whereas USA patients were more commonly discharged to an alternative healthcare provider (66·14% vs 19·14%, p<0·001), including 24% discharged to a skilled nursing facility [Table 2]. The discrepancy in discharge destinations provides important context for the present study's comparison of in-hospital mortality. Although a similar proportion of hospitals were described as teaching institutions in both countries (15·14% vs 17·35%, p=0·495), a greater proportion of rAAA in the USA were treated at teaching institutions (51·53% vs 29·29%, p<0·001, Table 1).

Predictors of In Hospital Mortality and Non-Corrective Treatment in England and the USA

Mortality was lower at teaching institutions than non-teaching institutions in both countries (England - 56·04% vs 69·99% and USA - 48·43% vs 58·05%, p<0·001) [Table 2]. The non-corrective treatment rate was also lower in teaching institutions in both countries (England - 31·32% vs 45·63% and USA - 14·93% vs 24·62% , p<0·001). EVAR was more prevalent in teaching institutions (England - 6·14% vs 13·12% and USA - 15·54% vs 25·35%, p<0·001). In both countries, mortality and non-corrective treatment rates were better in hospitals with the highest bed capacity [Table 3], in patients who were transferred, and in patients treated on a weekday rather than a weekend (see Supplementary Appendix).

After adjusting for age, gender, co-morbidity, year and hospital size/caseload; predictors of mortality in England included admission on a weekend rather than a weekday (OR 1·144, 95% CI 1·037-1·263, p=0·007), inter-hospital transfer rather than treatment in the presenting hospital (OR 0·646, 95% CI 0·563-0·739, p<0·001), and treatment outside a teaching institution (OR 1·462, 95% CI 1·310-1·631, p<0·001) [see Supplementary Appendix]. In the USA, predictors of mortality included admission on a weekend (OR 1·156, 95% CI 1·005-1.337, p=0·043) and treatment outside a teaching institution (OR 1·272, 95% CI 1·037-1·560, p=0·024). After risk adjustment in England, non-corrective treatment was more likely in patients admitted over a weekend (OR 1·274, 95% CI 1·154-1·407, p<0·001) or treated at non-teaching institutions (OR 1·459, 95% CI 1·301-1·636, p<0·001). Non-corrective treatment was less likely after inter-hospital transfer in both England (OR 0·431, 95% CI 0·367-0·507, p<0·001) and the USA (OR 0·637, 95% CI 0·431- 0·943, p=0·024).

DISCUSSION

The main finding of this study was that the in-hospital mortality of patients with rAAA was considerably lower in the USA than in England. This was principally because USA hospitals were less likely to manage rAAA by non-corrective treatment and offered aneurysm repair to a significantly greater proportion of patients. Although operative mortality rates were similar, patients in the USA were more than twice as likely to be offered rEVAR and were more often managed in a teaching hospital, compared to England.

The proportion of patients offered intervention (rEVAR or open repair) in the USA presented a stark difference to England, and provides important context for improving English practice.[13,14] Previous studies of Medicare beneficiaries in the USA have reported that 68% of patients with rAAA were offered intervention.[15,16] Although this was lower than the estimate of 80% from the present study and other NIS reports, the proportion offered intervention in the USA has been consistently reported to be greater than in England.[3] Post-operative mortality was similar in both countries, suggesting that overall survival from rAAA in England would be improved by offering intervention to a greater proportion of patients, to lower the rate of non-corrective treatment. Published clinical data support this theory, and have demonstrated that an aggressive management strategy with a lower rate of non-corrective treatment results in lower overall mortality from rAAA.

The data did not permit reporting of 30-day mortality and it should be noted that a greater proportion of patients were discharged to a healthcare provider in the USA compared to England, where most patients were discharged home. The proportion of patients that died after discharge from the primary facility is unknown. Comparisons of in-hospital mortality should therefore be interpreted with a degree of caution to acknowledge the risk of confounding by different discharge policies. Further research should also investigate international disparities in 90-day mortality rates, which may mitigate against differences in critical care provision. However, it remains unlikely that the 13% absolute mortality difference could be entirely explained by deaths in secondary care given the stark difference in non-corrective treatment rates.

Previous studies have shown that the outcome of rAAA repair is partly determined by patient-level factors including age, gender and co-morbidity.[17–21] The present study adds new insights by demonstrating that common hospital-level factors influenced outcomes in both healthcare systems. In both countries, in-hospital mortality was more likely in patients treated on a weekend rather than a weekday, or in patients treated outside a "teaching" institution.

In both England and the USA, the best outcomes were obtained in hospitals with the highest bed capacity, the greatest annual caseload (volume) of rAAA, and in hospitals in which a larger proportion of rAAA were managed by rEVAR. These findings add to previous evidence that a volume-outcome relationship exists for operative mortality after rAAA in both England and America.[22,23] Hospital bed size, teaching status, admission on a weekday and rAAA caseload might all be regarded as inter-related surrogate markers for the immediacy with which each rAAA patient had access to the full range of technology and care by a specialist multidisciplinary team.

Previous studies have demonstrated higher mortality associated with weekend admission for a range of emergency conditions in the English National Health Service.[24,25] The international data presented here reinforce these concerns and illustrate that the challenge of providing high-quality out-of-hours care is widespread. The results from the present study suggest that service configuration should focus on ensuring that patients with a ruptured AAA are treated in a teaching hospital with a high aortic workload, offering both conventional and endovascular repair.

The present study demonstrated superior outcomes in those treated by endovascular as compared to open repair in both England and the USA, and was consistent with other large studies documenting the outcomes of clinical practice. In the elective setting, randomised trials have consistently demonstrated lower operative mortality after EVAR for non-ruptured AAA, but this finding has not been replicated by a randomised trial for rAAA patients. Nonetheless, the evidence from national outcomes research remains compellingly in favour of rEVAR, and for many experts the role for a randomised study of rEVAR versus open repair remains controversial. Due to the design of the study, the endovascular outcomes could not be adjusted for aortic morphology or haemodynamic status. There was a significant difference in the utilisation of endovascular repair with a threefold greater uptake of rEVAR in the USA. It has been shown that approximately 50% of patients with rAAA are morphologically suitable for rEVAR, yet the adoption of rEVAR in both countries remained short of this benchmark[28].

The limitations of this study relate to the observational nature of the administrative datasets that were analysed. However there was clear evidence that the outcomes of rAAA in England are worse than in the USA. In-hospital mortality is higher in England and this appears attributable to the lower proportion offered intervention. The uptake of rEVAR is low in England. Common hospital-level factors were associated with mortality from rAAA in both countries and should inform improvements to service configuration.

Conflicts of interest:

None

Authors' contributions:

Alan Karthikesalingam: conception and design, analysis and interpetation, drafting and revision of manuscript, final approval of version for publication.

Peter J Holt: design, interpetation, drafting and revision of manuscript, final approval of version for publication.

Alberto Vidal-Diez: design, analysis, interpetation, revision of manuscript, final approval of version for publication.

Baris A Ozdemir: design, interpetation, and revision of manuscript, final approval of version for publication.

Jan D Poloniecki: design, analysis, revision of manuscript, final approval of version for publication.

Robert J Hinchliffe: design, interpretation, revision of manuscript, final approval of version for publication.

Matthew M Thompson: conception and design, analysis and interpetation, drafting and revision of manuscript, final approval of version for publication, guarantor of work.

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Table 1: Primary Outcomes after rAAA in England and USA.

	England	USA (95% confidence interval)	P-value
Number of Patients	11799	23838	
Operated Patients (n, %)	6897 (58·45%)	19174 (80·43%) (78·99% - 81·88%)	< 0·001
In-hospital Mortality (%)	65·90%	53·05% (51·26% - 54·85%)	< 0·001
Post-operative Mortality (%)	41·77%	41·65% (39·93% - 43·39%)	0·88
rEVAR (%)	8·54%	20·87% (18·59% - 23·16%)	< 0·001
Open repair mortality (%)	42·72%	45·57% (43·6% - 47·54%)	< 0·001
rEVAR mortality (%)	31·58%	26·84%	0.018
Length of Stay Median (IQR)	Overall 4(13) Dead in hospital 1(4) Survivors 16(18)	Overall 4.6 (11.9) Dead in hospital 0.44 (2.3) Survivors 10.59 (12.45)	
% Discharged Home	79·99%	33·70% (31·42%-35·98%)	<0·001
% Discharged to other healthcare provider	19·17%	66·14% (63·87%-68·42%)	<0·001
% Teaching Hospitals in analysis	15·14%	17·35% (16·68% - 18·01%)	0·50
% rAAA Treated in Teaching Hospital	29·29%	51·53% (48·32%-54·76%)	<0·001

* 95% confidence intervals are provided for USA data, to reflect the precision of the sample-derived national estimates. Data for England are not derived from a sample and therefore no confidence intervals are required.

Table 2: Comparison of outcomes in teaching and non-teaching hospitals in England and USA

	Teaching hospital England	Non-teaching Hospital England	p-value	Teaching hospital USA	Non-teaching hospital USA	p-value
All mortality (operated and non-operated)	56·04%	69·99%	<0·001	48·43% (45·89% - 50·98%)	58·05% (55·74% - 60·37%)	<0·001
Operative mortality (operated cases only)	35·99%	44·8%	<0·001	39·43% (37·1% - 41·77%)	44·35% (41·88%- 46·83%)	<0·001
% of Operated cases done by EVAR	13·12%	6·14%	<0·001	25·35% (21·92%- 28·78%)	15·54% (12·96%- 18·12%)	<0·001
Non-corrective treatment rate (% of all cases that are not operated)	31·32%	45·63%	<0·001	14·93% (13·07%- 16·79%)	24·62% (22·55%- 26·73%)	<0·001
Mortality EVAR	28·62%	34·89%	0·1104	25·19% (21·53% - 28·84%)	30·54% (24·48%- 36·6%)	<0·001
Mortality Open	37·11%	45·45%	<0·001	44·27% (41·42%- 47·12%)	46·89% (44·22%- 49·56%)	0·001

Table 3: Comparison of outcomes in low-volume, middle-volume and high-volume hospitals in England and USA.

	Low-bed capacity England (% of total)	Middle bed capacity England	High-bed capacity england	Low bed capacity USA	Middle bed capacity USA	High bed capacity USA
All mortality (operated and non-operated)	82·56%	68·64%	61·89%	75·86% (73·31 - 78·42)	51·33% (48·38 - 54·27)	43·82% (41·53 - 46·1)
Operative mortality (operated cases only)	46·32%	44·65%	40·18%	50·64% (46·25%-55·03%)	44% (40·96%-47·06%)	38·32% (36·12%-40·53%)
% of Operated cases done by EVAR	9·21%	7·03%	9·12%	16·27%	17·43%	23·73%
Non-corrective treatment rate (% of all cases that are not operated)	67·52%	43·34%	36·29%	51·29% (48·49%-54·09%)	13·07% (11·15%-15%)	8·91% (7·67%-10·14%)
Mortality EVAR	25·71%	36·76%	30·38%	34·45% (24·43%-44·48%)	29·77% (23·09%-36·47%)	24·49% (20·7%-28·28%)
Mortality Open	48·41%	45·25%	41·16%	53·79% (49·06%-58·51%)	47·01% (43·69%-50·34%)	42·63% (39·97%-45·29%)

Figure 1: In-hospital Mortality for rAAA after person-level matching for gender and 5-year age grouping. p<0·0001 for paired comparison of England versus America; McNemar’s test.

Figure 2: Non-corrective treatment for rAAA after person-level matching for gender and 5-year age grouping. p<0·0001 for within-strata comparison of England versus America; McNemar’s test.

Supplementary Appendix 1: Patient Characteristics in England and USA

Variable	England	USA	P-value
Mean Age (SD)	78·19 (8·01)	76·58 (9·58)	< 0·001
% Male	73·68%	71·41% (70% - 72·81%)	<0·001
Myocardial Infarction	8·8%	14·81% (13·76% - 15·86%)	<0·001
Congestive Heart Failure	15·07%	15·09% (14·05% - 16·13%)	0·97
Cerebrovascular disease	11·7%	4·33% (3·74% - 4·9%)	<0·001
Dementia	5·27%	2·13% (1·72% - 2·55%)	<0·001
Chronic Pulmonary Disease	23·81%	32·16% (30·76% - 33·57%)	<0·001
Connective Tissue Disease	3·09%	1·4% (1·08% - 1·72%)	<0·001
Liver Disease	2·26%	5·32% (4·66% - 5·97%)	<0·001
Diabetes	10·53%	12·7% (11·73% - 13·66%)	<0·001
Paraplegia	2·55%	0·99% (0·72% - 1·26%)	<0·001
Renal disease	12·09%	15·06% (13·94% - 16·18%)	<0·001
Any Malignancy	9·29%	3·36% (2·85% - 3·86%)	<0·001
Metastatic Carcinoma	1·28%	0·96% (0·69% - 1·23%)	0·007

Supplementary Appendix 2: Comparison of outcomes in patients who are transferred in England and USA

	Transferred Patients England	Non-transferred patients England	p-value	Transferred Patients USA	Non-transferred patients USA	p-value
All mortality (operated and non-operated)	51·96%	67·56%	<0·001	40·52% (35·66%-45·37%)	52·58% (50·16% - 55%)	<0·001
Operative mortality (operated cases only)	37·75%	42·43%	0·006	34·42% (30·08%-38·75%)	40·05% (37·57%-42·54%	<0·001
% of Operated cases done by EVAR	8·75%	7·24%	0·12	31·33% (25·44%-37·22%)	26·01% (22·85%-29·17%)	<0·001
Non-corrective treatment rate (% of all cases that are not operated)	22·83%	43·65%	<0·001	9·31% (6·1%-12·51%	20·98% (18·92%-23·04%)	<0·001
Mortality EVAR	27·14%	32·18%	0·49	23·87% (17·02%-30·74%)	23·68% (19·76%-27·6%)	0·92
Mortality Open	38·57%	43·41%	0·007	39·23% (33·29%-45·16%)	45·81% (42·86%-48·75%)	<0·001

Supplementary Appendix 3: Comparison of outcomes on weekends and weekdays in England and USA

	Weekday England	Weekend England	p-value	Weekday USA	Weekend USA	p-value
All mortality (operated and non-operated)	65·27%	67·67%	0·005	52·51% (50·48%-54·52%)	54·52% (51·72%-57·31%)	0·006
Operative mortality (operated cases only)	41·87%	41·48%	0·98	40·86% (38·85%-42·88%)	43·76% (40·8%-46·7%)	<0·001
% of Operated cases done by EVAR	8·77%	7·85%	0·25	21·48% (19·06%-23·9%)	19·29% (16·25%-22·33%)	<0·001
Non-corrective treatment rate (% of all cases that are not operated)	40·26%	44·76%	<0·001	19·73% (18·15%-21·31%)	19·13% (16·8%-21·46%)	0·30
Mortality EVAR	31·87%	30·6%	0·83	24·8% (21·37%-28·26%)	32·79% (26·23%-39·36%)	<0·001
Mortality Open	42·83%	42·4%	0·77	45·26% (42·97%-47·54%)	46·38% (42·95%-49·8%)	0·22

Supplementary Appendix 4: Logistic Regression Models of In-hospital Mortality in England and USA. Models risk-adjusted for Age, Gender and Co-morbidity Index.

Covariate	HES (England)		NIS (USA)	
	OR (95% CI)	*p-value*	*OR (95% CI)*	*p-value*
Weekend Admission	1·144 1·037-1·263	0·007	1·156 1·005-1.337	0·043
Transfer**	0·646 0·563-0·739	<0·001	0·839 0·662-1·064	0·15
Non-Teaching Institution	1·462 1·310-1·631	<0·001	1·272 1·037-1·560	0·023
Institutional rAAA Volume	*	<0·001	*	<0·001
Region	*	<0·001	*	0·099
Year	*	<0·001	*	<0·001
Hospital size (Number of beds)	*	0·46	*	0·10
Rural location	Not available	-	0·987 0·739-1·318	0·93
Hospital control	Only public hospitals	-	*	0·013

*Odds ratios for categorical comparisons.
** NIS data only available from 2008 onwards.

Supplementary Appendix 5: Logistic Regression Models of Non-Corrective Treatment (Conservative or Palliative Management) for rAAA in England and USA. Models risk-adjusted for Age, Gender and Co-morbidity.

Covariate	HES (England)		NIS (USA)	
	OR (95% CI)	*p-value*	*OR (95% CI)*	*p-value*
Weekend Admission	1·274 1·154-1·407	<0·001	1·005 0·818-1.235	0·96
Transfer	0·431 0·367-0·507	<0·001	0·637 (0·431-0·943)	0·024
Non-Teaching Institution	1·459 1·301-1·636	<0·001	1·029 0·704-1·504	0·74
Institutional rAAA Volume	*	<0·001	*	<0·001
Region	*	<0·001	*	0·001
Year	*	<0·001	*	0·36
Hospital size (number of beds)	*	0·73	*	0·10
Rural location	Not available		1·339 0·961-1·867	0·085

Hospital control	Only public hospitals		*	0·75

Supplementary Appendix 6: Logistic Regression modelling of Operative Mortality in England and USA. Models risk-adjusted for Age, Gender and Co-morbidity.

Covariate	HES (England)		NIS (USA)	
	OR (95% CI)	*p-value*	*OR (95% CI)*	*p-value*
Open repair	1·773 1·459-2·154	< 0·001	2·299 1·908-2·769	<0·001
Weekend Admission	1·004 0·895-1·127	0·94	1·180 1·012-1·375	0·035
Transfer	0·866 0·746-1·006	0·060	1·101 0·852-1·421	0·46
Non-Teaching Institution	1·246 1·096-1·416	<0.001	1·235 0·987-1·544	0·06
Institutional rAAA Volume	*	0·037	*	<0·001
Region	*	0·004	*	0·007
Year	*	0·001	*	0·002
Hospital size (number of beds)	*	0·65	*	0·06
Rural location	Not available		0·857 0·62-1·184	0·35
Hospital control	Only public hospitals		*	0·06