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BJS11006**Sex differences in national rates of repair of emergency abdominal aortic aneurysm**

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Table S1 OPCS codes for open repair of infra-renal AA

OPCS Code	OPCS Description
L184	Emergency replacement of aneurysmal segment of infrarenal abdominal aorta by anastomosis of aorta to aorta
L185	Emergency replacement of aneurysmal segment of abdominal aorta by anastomosis of aorta to aorta NEC
L186	Emergency replacement of aneurysmal bifurcation of aorta by anastomosis of aorta to iliac artery
L188	Other specified emergency replacement of aneurysmal segment of aorta
L189	Unspecified emergency replacement of aneurysmal segment of aorta
L194	Replacement of aneurysmal segment of infrarenal abdominal aorta by anastomosis of aorta to aorta NEC
L195	Replacement of aneurysmal segment of abdominal aorta by anastomosis of aorta to aorta NEC
L196	Replacement of aneurysmal bifurcation of aorta by anastomosis of aorta to iliac artery NEC
L198	Other specified other replacement of aneurysmal segment of aorta
L199	Unspecified other replacement of aneurysmal segment of aorta
L204	Emergency bypass of segment of infrarenal abdominal aorta by anastomosis of aorta to aorta NEC
L205	Emergency bypass of segment of abdominal aorta by anastomosis of aorta to aorta NEC
L214	Bypass of segment of infrarenal abdominal aorta by anastomosis of aorta to aorta NEC
L215	Bypass of segment of abdominal aorta by anastomosis of aorta to aorta NEC
L254	Operations on aneurysm of aorta NEC
L481	Emergency replacement of aneurysmal common iliac artery by anastomosis of aorta to common iliac artery
L482	Emergency replacement of aneurysmal iliac artery by anastomosis of aorta to external iliac artery
L483	Emergency replacement of aneurysmal artery of leg by anastomosis of aorta to common femoral artery
L484	Emergency replacement of aneurysmal artery of leg by anastomosis of aorta to superficial femoral artery
L485	Emergency replacement of aneurysmal iliac artery by anastomosis of iliac artery to iliac artery
L486	Emergency replacement of aneurysmal artery of leg by anastomosis of iliac artery to femoral artery
L488	Other specified emergency replacement of aneurysmal iliac artery
L489	Unspecified emergency replacement of aneurysmal iliac artery
L491	Replacement of aneurysmal common iliac artery by anastomosis of aorta to common iliac artery NEC
L492	Replacement of aneurysmal iliac artery by anastomosis of aorta to external iliac artery NEC
L493	Replacement of aneurysmal artery of leg by anastomosis of aorta to common femoral artery NEC
L494	Replacement of aneurysmal artery of leg by anastomosis of aorta to superficial femoral artery NEC

L495	Replacement of aneurysmal iliac artery by anastomosis of iliac artery to iliac artery NEC
L496	Replacement of aneurysmal artery of leg by anastomosis of iliac artery to femoral artery NEC
L498	Other specified other replacement of aneurysmal iliac artery
L499	Unspecified other replacement of aneurysmal iliac artery
L533	Operations on aneurysm of iliac artery NEC

Table S2 OPCS codes for endovascular repair of infra-renal AA

OPCS Code	OPCS Description
L271	Endovascular insertion of stent graft for infrarenal abdominal aortic aneurysm
L275	Endovascular insertion of stent graft for aortic aneurysm of bifurcation NEC
L276	Endovascular insertion of stent graft for aorto-uniiliac aneurysm
L278	Other specified transluminal insertion of stent graft for aneurysmal segment of aorta
L279	Unspecified transluminal insertion of stent graft for aneurysmal segment of aorta
L281	Endovascular insertion of stent for infrarenal abdominal aortic aneurysm
L285	Endovascular insertion of stent for aortic aneurysm of bifurcation NEC
L286	Endovascular insertion of stent for aorto-uniiliac aneurysm
L288	Other specified transluminal operations on aneurysmal segment of aorta
L289	Unspecified transluminal operations on aneurysmal segment of aorta

Table S3 OPCS codes for Aorto-iliac bypass, aortic/iliac endarterectomy or repair

OPCS Code	OPCS Description
L206	Emergency bypass of bifurcation of aorta by anastomosis of aorta to iliac artery NEC
L208	Other specified other emergency bypass of segment of aorta
L209	Unspecified other emergency bypass of segment of aorta
L216	Bypass of bifurcation of aorta by anastomosis of aorta to iliac artery NEC
L218	Other specified other bypass of segment of aorta
L219	Unspecified other bypass of segment of aorta
L222	Revision of prosthesis of bifurcation of aorta
L223	Revision of prosthesis of abdominal aorta NEC
L224	Removal of prosthesis from aorta
L228	Other specified attention to prosthesis of aorta
L229	Unspecified attention to prosthesis of aorta
L231	Plastic repair of aorta and end to end anastomosis of aorta
L232	Plastic repair of aorta using subclavian flap
L233	Plastic repair of aorta using patch graft
L238	Other specified plastic repair of aorta
L239	Unspecified plastic repair of aorta
L251	Endarterectomy of aorta and patch repair of aorta
L252	Endarterectomy of aorta NEC
L255	Operations on aortic body
L258	Other specified other open operations on aorta
L259	Unspecified other open operations on aorta
L501	Emergency bypass of common iliac artery by anastomosis of aorta to common iliac artery NEC
L502	Emergency bypass of iliac artery by anastomosis of aorta to external iliac artery NEC
L503	Emergency bypass of artery of leg by anastomosis of aorta to common femoral artery NEC
L504	Emergency bypass of artery of leg by anastomosis of aorta to deep femoral artery NEC
L505	Emergency bypass of iliac artery by anastomosis of iliac artery to iliac artery NEC
L506	Emergency bypass of artery of leg by anastomosis of iliac artery to femoral artery NEC
L508	Other specified other emergency bypass of iliac artery
L509	Unspecified other emergency bypass of iliac artery
L511	Bypass of common iliac artery by anastomosis of aorta to common iliac artery NEC
L512	Bypass of iliac artery by anastomosis of aorta to external iliac artery NEC
L513	Bypass of artery of leg by anastomosis of aorta to common femoral artery NEC
L514	Bypass of artery of leg by anastomosis of aorta to deep femoral artery NEC
L515	Bypass of iliac artery by anastomosis of iliac artery to iliac artery NEC
L516	Bypass of artery of leg by anastomosis of iliac artery to femoral artery NEC
L518	Other specified other bypass of iliac artery
L519	Unspecified other bypass of iliac artery
L521	Endarterectomy of iliac artery and patch repair of iliac artery
L522	Endarterectomy of iliac artery NEC

L528	Other specified reconstruction of iliac artery
L529	Unspecified reconstruction of iliac artery
L531	Repair of iliac artery NEC
L538	Other specified other open operations on iliac artery
L539	Unspecified other open operations on iliac artery
L651	Revision of reconstruction involving aorta
L652	Revision of reconstruction involving iliac artery

Table S4 ICD-10 codes for Aortic Aneurysm Rupture

ICD-10 Code	ICD-10 Description
I713	Abdominal aortic aneurysm, ruptured
I718	Aortic aneurysm of unspecified site, ruptured

Table S5 ICD-10 codes for Aortic Aneurysm with no mention of rupture

ICD-10 Code	ICD-10 Description
I714	Abdominal aortic aneurysm, without mention of rupture
I719	Aortic aneurysm of unspecified site, without mention of rupture

Appendix S1 Abdominal aortic aneurysm diagnosis codes (ICD-10) & procedure codes (OPCS)

AAA-related deaths without any repair included those patients admitted with a diagnosis of AAA and died with no record of repair in that admission or in previous admissions. Investigations were done to examine both the delay between intervention (*Table S6*) and death as well as the presence of early interventions (*Table S7*). Procedure fields of all episodes within the index admissions were investigated for evidence of early interventions (For details see *Table S8*).

Table S6 AA-related deaths without any repair by delay from admission day to death

Admission Method	Delay from admission to death	Number of cases	%
Emergency	0 day	4,475	35.1%
	1 day	3,246	25.4%
	2 days	1,223	9.6%
	>= 3 days	3,599	28.2%
Elective	0 day	18	0.1%
	1 day	29	0.2%
	2 days	18	0.1%
	>= 3 days	159	1.2%
TOTAL		12,767	100%

Table S7 AA related death divided based on presence of OPCS codes indicative of early management of ruptured AA

Early interventions OPCS codes	Total number of cases
No early interventions	11,881 (93.1%)
Early interventions	886 (6.9%)
Total	12,767 (100%)

Table S8 OPCS codes for possible early interventions

Y502	Laparotomy approach NEC
Y701	Emergency operations NOC
L704	Open cannulation of artery
L911	Open insertion of central venous catheter
L912	Insertion of central venous catheter NEC
L913	Attention to central venous catheter NEC
L914	Removal of central venous catheter

L915	Insertion of tunnelled venous catheter
U011	Computed tomography of whole body
U012	Magnetic resonance imaging of whole body
U018	Other specified diagnostic imaging of whole body
U019	Unspecified diagnostic imaging of whole body
U071	Computed tomography of chest
U072	Magnetic resonance imaging of chest
U078	Other specified diagnostic imaging of chest
U079	Unspecified diagnostic imaging of chest
U081	Computed tomography of abdomen NEC
U082	Ultrasound of abdomen
U085	Magnetic resonance imaging of abdomen
U089	Unspecified diagnostic imaging of abdomen
U091	Computed tomography of pelvis
U113	Vascular ultrasound NEC
U117	Magnetic resonance angiography
U118	Other specified diagnostic imaging of vascular system
U119	Unspecified diagnostic imaging of vascular system
U216	Ultrasound scan NEC
U218	Other specified diagnostic imaging procedures
U219	Unspecified diagnostic imaging procedures

Appendix S2 Development of aortic aneurysm modified Charlson comorbidity index

The Charlson ICD-10 based comorbidity instrument (Quan et al. 2005) described 17 disease categories (Table S9) and the RCS Charlson comorbidity (Armitage et al. 2010) instruments described 14 categories (Table S10). The frequency of each disease category described in either of these instruments were calculated.

Table S9 Charlson ICD-10 based comorbidity categories (Quan et al. 2005)

Number	Charlson Comorbidity Category	ICD-10 codes/blocks
1	Myocardial Infarction	I21.x, I22.x, I25.2
2	Congestive Heart Failure	I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5–I42.9, I43.x, I50.x, P29.0
3	Peripheral Vascular Disease	I70.x, I71.x, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9
4	Cerebrovascular Disease	G45.x, G46.x, H34.0, I60.x–I69.x
5	Dementia	F00.x–F03.x, F05.1, G30.x, G31.1
6	Chronic Pulmonary Disease	I27.8, I27.9, J40.x–J47.x, J60.x–J67.x, J68.4, J70.1, J70.3
7	Connective Tissue Disease-Rheumatic Disease	M05.x, M06.x, M31.5, M32.x–M34.x, M35.1, M35.3, M36.0
8	Peptic Ulcer Disease	K25.x–K28.x
9	Mild Liver Disease	B18.x, K70.0–K70.3, K70.9, K71.3–K71.5, K71.7, K73.x, K74.x, K76.0, K76.2–K76.4, K76.8, K76.9, Z94.4
10	Diabetes without chronic complications	E10.0, E10.1, E10.6, E10.8, E10.9, E11.0, E11.1, E11.6, E11.8, E11.9, E12.0, E12.1, E12.6, E12.8, E12.9, E13.0, E13.1, E13.6, E13.8, E13.9, E14.0, E14.1, E14.6, E14.8, E14.9
11	Diabetes with chronic complications	E10.2–E10.5, E10.7, E11.2–E11.5, E11.7, E12.2–E12.5, E12.7, E13.2–E13.5, E13.7, E14.2–E14.5, E14.7
12	Paraplegia and Hemiplegia	G04.1, G11.4, G80.1, G80.2, G81.x, G82.x, G83.0–G83.4, G83.9
13	Renal Disease	I12.0, I13.1, N03.2–N03.7, N05.2–N05.7, N18.x, N19.x, N25.0, Z49.0–Z49.2, Z94.0, Z99.2
14	Any malignancy, including lymphoma and leukemia, except malignant neoplasm of skin	C00.x–C26.x, C30.x–C34.x, C37.x–C41.x, C43.x, C45.x–C58.x, C60.x–C76.x, C81.x–C85.x, C88.x, C90.x–C97.x

15	Moderate or Severe Liver Disease	I85.0, I85.9, I86.4, I98.2, K70.4, K71.1, K72.1, K72.9, K76.5, K76.6, K76.7
16	Metastatic Carcinoma	C77.x–C80.x
17	AIDS/HIV	B20.x–B22.x, B24.x

Table S10 Royal College of Surgeons Charlson ICD-10 based comorbidity categories

Number	Disease Category	ICD-10 Codes/blocks
1	Myocardial infarction	I21*, I22*, I23*, I252
2	Congestive cardiac failure	I11, I13, I255, I42, I43, I50, I517
3	Peripheral vascular disease	I70–I73, I770, I771, K551, K558, K559, R02, Z958, Z959
4	Cerebrovascular disease	G45, G46, I60–I69
5	Dementia	A810, F00–F03, F051, G30, G31
6	Chronic pulmonary disease	I26, I27, J40–J45, J46*, J47, J60–J67, J684, J701, J703
7	Rheumatological disease	M05, M06, M09, M120, M315, M32–M36
8	Liver disease	B18, I85, I864, I982, K70, K71, K721, K729, K76, R162, Z944
9	Diabetes mellitus	E10–E14
10	Hemiplegia or paraplegia	G114, G81–G83
11	Renal disease	I12, I13, N01, N03, N05, N07, N08, N171*, N172*, N18, N19*, N25, Z49, Z940, Z992
12	Any malignancy	C00–C26, C30–C34, C37–C41, C43, C45–C58, C60–C76, C80–C85, C88, C90–C97
13	Metastatic solid tumour	C77–C79
14	AIDS/HIV infection	B20–B24

*Indicates an acute condition that should be used to define co-morbidity only if present in a record of a previous hospital admission within the preceding 12 months.

The vascular comorbidity consensus group (VCCG) (AA, JAM, SN, WAJ, ST) was presented with the frequency of each disease category in the index admission and previous admission as well as the results of the regression analysis of Charlson ICD-10 index and the RCS Charlson score. The VCCG suggested the following based the data presented and clinical evidence:

- 1- Exclude the following four disease categories: peripheral arterial disease category (number 3) since 97% of patients included in the dataset have this comorbidity, dementia category (number 5) as only 553 patients had the disease (0.7% of all patients), connective tissue disease-Rheumatic disease category (number 7) since only 1.7% of patients had this disease and the regression analyses revealed that it had no effect on mortality or length of stay and AIDS/HIV category as only there were 12 cases-0.01% of total patients.

- 2- Merge diabetes categories (10&11) together and do the same with cancer categories (14&16) in the same fashion as RCS Charlson categories.
- 3- Modify the myocardial infarction category to include all coronary artery disease. This was based on clinical opinion and also inconsistency in HES coding.
- 4- Congestive Heart Failure category was updated to 'Heart Failure'. Some of the paediatric ICD10 codes were dropped because they were not relevant. Some new ICD10 codes/blocks were added (*Table S11*).
- 5- For categories 1, 2, 4, 8, 12 & 13 (myocardial infarction, congestive heart failure, cerebrovascular disease, peptic ulcer disease, paraplegia & hemiplegia and renal disease) count as comorbidity if they appear in previous admissions.

Table S11 Sheffield AAA modified Charlson Comorbidities categories

No	Comorbidity Category	ICD-10 codes/blocks	Note
1	Coronary Artery Disease	I20.x, I21.x, I22.x, I23.x, I24.x, I25.x	Not count as a comorbidity if only present in the index admission
2	Heart Failure	I50.x, I43.x, I42.x, I09.9, I11.0, I13.0, I13.2, I25.5, I51.7	Not count as a comorbidity if only present in the index admission
3	Cerebrovascular Disease	G45.x, G46.x, H34.0, I60.x–I69.x	Not count as a comorbidity if only present in the index admission
4	Chronic Pulmonary Disease	I27.8, I27.9, J40.x–J47.x, J60.x–J67.x, J68.4, J70.1, J70.3	Count in both index and pre-index admissions
5	Peptic Ulcer Disease	K25.x–K28.x	Not count as a comorbidity if only present in the index admission
6	Mild Liver Disease	B18.x, K70.0–K70.3, K70.9, K71.3–K71.5, K71.7, K73.x, K74.x, K76.0, K76.2–K76.4, K76.8, K76.9, Z94.4	Count in both index and pre-index admissions

7	Diabetes	E10.0, E10.1, E10.6, E10.8, E10.9, E11.0, E11.1, E11.6, E11.8, E11.9, E12.0, E12.1, E12.6, E12.8, E12.9, E13.0, E13.1, E13.6, E13.8, E13.9, E14.0, E14.1, E14.6, E14.8, E14.9, E10.2–E10.5, E10.7, E11.2–E11.5, E11.7, E12.2–E12.5, E12.7, E13.2–E13.5, E13.7, E14.2–E14.5, E14.7	Count in both index and pre-index admissions
8	Paraplegia and Hemiplegia	G04.1, G11.4, G80.1, G80.2, G81.x, G82.x, G83.0–G83.4, G83.9	Not count as a comorbidity if only present in the index admission
9	Renal Disease	I12.0, I13.1, N03.2–N03.7, N05.2–N05.7, N18.x, N19.x, N25.0, Z49.0–Z49.2, Z94.0, Z99.2	Not count as a comorbidity if only present in the index admission
10	Cancer	C00.x–C26.x, C30.x–C34.x, C37.x–C41.x, C43.x, C45.x–C58.x, C60.x–C76.x, C81.x–C85.x, C88.x, C90.x–C97.x, C77.x–C80.x	Relevant for emergency or when cancer is diagnosed in the index admission
11	Moderate or Severe Liver Disease	I85.0, I85.9, I86.4, I98.2, K70.4, K71.1, K72.1, K72.9, K76.5, K76.6, K76.7	Count in both index and pre-index admissions
12	Smoking	Z720', 'F171', 'F172', 'F173', 'F174', 'F175', 'F176', 'F177', 'F178', 'F179'	New group, investigate
13	Obesity	E660', 'E661', 'E662', 'E668', 'E669'	New group, investigate
14	Primary hypertension	I10X	New group, investigate
15	Dyslipidemia	E780', 'E782', 'E784', 'E785'	New group, investigate

References:

Armitage JN, van der Meulen JH; Royal College of Surgeons Co-morbidity Consensus Group. Identifying co-morbidity in surgical patients using administrative data with the Royal College of Surgeons Charlson Score. *Br J Surg.* 2010 May;97(5):772-81.

Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, Saunders LD, Beck CA, Feasby TE, Ghali WA. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care.* 2005 Nov;43(11):1130-9.

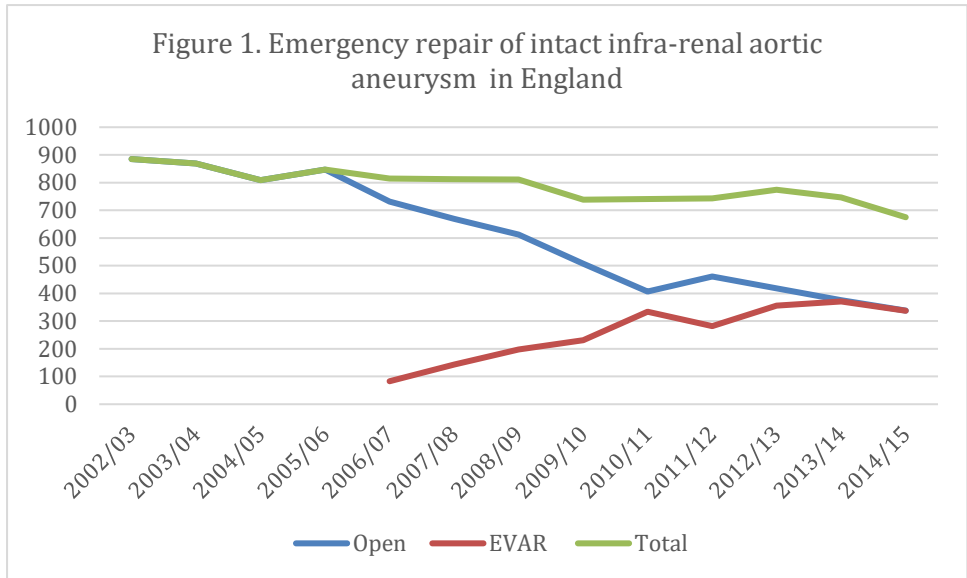


Fig. S1 Trends over time for the type of emergency repair received by patients presenting with intact AAA

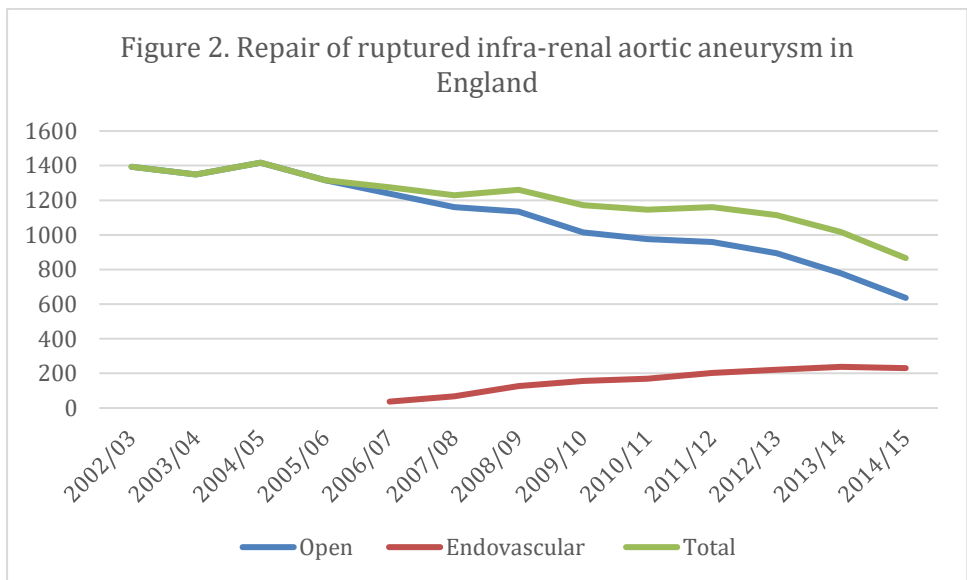


Fig. S2 Trends over time for the type of emergency repair received by patients presenting with ruptured AAA