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The Impact of Centralisation and Endovascular Aneurysm Repair on Treatment of Ruptured Abdominal Aortic Aneurysms Based on International Registries

Jacob Budtz-Lilly [a,b,*], Martin Björck [a], Maarit Venermo [c], Sebastian Debus [d], Christian-Alexander Behrendt [d], Martin Altreuther [e], Barry Beiles [f], Zoltan Szeberin [g], Nikolaj Eldrup [b], Gudmundur Danielsson [h], Ian Thomson [i], Pius Wigger [j], Manar Khashram [k], Ian Loftus [l], Kevin Mani [a]

[a] Department of Surgical Sciences, Vascular Surgery, Uppsala University, Uppsala, Sweden
[b] Department of Cardio-Thoracic and Vascular Surgery, Aarhus University Hospital, Aarhus, Denmark
[c] Department of Vascular Surgery, Helsinki University Hospital, Helsinki, Finland
[d] Department of Vascular Medicine, University Heart Centre Hamburg — Eppendorf, Hamburg, Germany
[e] Department of Vascular Surgery, St Olavs Hospital, Trondheim, Norway
[f] Australian and New Zealand Society for Vascular Surgery, East Melbourne, Australia
[g] Department of Vascular Surgery, Semmelweis University, Budapest, Hungary
[h] National University Hospital of Iceland, Department of Surgery, Reykjavík, Iceland
[i] Department of Vascular Surgery, Dunedin School of Medicine, Dunedin Hospital, Dunedin, New Zealand
[j] Department of Cardiovascular Surgery, Kantonsspital Winterthur, Switzerland
[k] Department of Surgery, University of Otago, Christchurch, New Zealand
[l] Department of Vascular Surgery, St George's University of London, London, UK

WHAT THIS PAPER ADDS

This international analysis assesses current trends and variations in the treatment of ruptured abdominal aortic aneurysms. The report indicates that outcomes after open repair of ruptured abdominal aortic aneurysms are better at centres with high volumes, while a substantial number of ruptured repairs are carried out at low volume centres. Hospitals that have a primary EVAR strategy for ruptures have an improved peri-operative mortality. This real world evidence could provide benchmarks for vascular surgery centres in their considerations of centralisation and implementation of endovascular aortic repair.

Objectives: Current management of ruptured abdominal aortic aneurysms (RAAA) varies among centres and countries, particularly in the degree of implementation of endovascular aneurysm repair (EVAR) and levels of vascular surgery centralisation. This study assesses these variations and the impact they have on outcomes.

Materials and methods: RAAA repairs from vascular surgical registries in 11 countries, 2010—2013, were investigated. Data were analysed overall, per country, per treatment modality (EVAR or open aortic repair [OAR]), centre volume (quintiles IV), and whether centres were predominantly EVAR ($\geq$50% of RAAA performed with EVAR [EVAR(p)]) or predominantly OAR [OAR(p)]. Primary outcome was peri-operative mortality. Data are presented as either mean values or percentages with 95% CI within parentheses, and compared with chi-square tests, as well as with adjusted OR.

Results: There were 9273 patients included. Mean age was 74.7 (74.5—74.9) years, and 82.7% of patients were men (81.9—83.6). Mean AAA diameter at rupture was 7.6 cm (7.5—7.6). Of these aneurysms, 10.7% (10.0—11.4) were less than 5.5 cm. EVAR was performed in 23.1% (22.3—24.0). There were 6817 procedures performed in OAR(p) centres and 1217 performed in EVAR(p) centres. Overall peri-operative mortality was 28.8% (27.9—29.8). Peri-operative mortality for OAR was 32.1% (31.0—33.2) and for EVAR 17.9% (16.3—19.6), $p < .001$, and the adjusted OR was 0.38 (0.31—0.47), $p < .001$. The peri-operative mortality was 23.0% in EVAR(p) centres (20.6—25.4), 29.7% in OAR(p) centres (28.6—30.8), $p < .001$; adjusted OR $=$ 0.60 (0.46—0.78), $p < .001$. Peri-operative mortality was lower in the highest volume centres (QI $>$ 22 repairs per year), 23.3% (21.2—25.4) than in QII-V, 30.0% (28.9—31.1), $p < .001$. Peri-operative mortality after OAR was lower in high volume centres compared with the other centres, 25.3% (23.0—27.6) and 34.0% (32.7—35.4), respectively, $p < .001$. There was no significant difference in peri-operative mortality after EVAR between centres based on volume.

* Corresponding author. Department of Surgical Sciences, Vascular Surgery, Uppsala University, Uppsala, Sweden.
E-mail address: jacobudt@rm.dk (Jacob Budtz-Lilly).
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Conclusions: Peri-operative mortality is lower in centres with a primary EVAR approach or with high case volume. Most repairs, however, are still performed in low volume centres and in centres with a primary OAR strategy. Reorganisation of acute vascular surgical services may improve outcomes of RAAA repair.
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INTRODUCTION

The mortality following repair of ruptured abdominal aortic aneurysm (RAAA) remains high, despite improvements in 30 day mortality, recently reported at around 30—35%.[1—5] The possible reasons for this improvement over time include better peri-operative and post-operative care, and the technological impact of endovascular aneurysm repair (EVAR).[6—8] It has been documented that the minimal invasiveness of EVAR reduces the morbidity and 30 day mortality of intact AAA treatment, particularly as the procedure can often be performed under local anaesthesia.[9—11] Indeed, EVAR is increasingly being used as the treatment modality of choice for intact AAAs in many countries. The rates for treating RAAA are still lagging, although they have reached as high as 40—50% in the United States and Australia.[12]

Several trials, including the recent Immediate Management of Patients with Ruptured Aneurysm: Open *Versus* Endovascular Repair (IMPROVE) trial, have aimed to assess the superiority of EVAR over open aortic repair (OAR) for ruptures.[4,13,14] As summarised in the meta-analysis by Sweeting et al., there was no difference in survival at 90 days, although women appear to benefit from an endovascular strategy.[15] However, the long-term results from the IMPROVE trial now reveal that an endovascular strategy offers improved survival at 3 years at a lower cost and a better quality of life, with no differences in the number of re-interventions.[16] Whether or not these results reflect general practice can be assessed in multinational vascular surgery databases, as their evaluation can shed light on real world differences in care and outcomes.[17] The objective of the present study is to report the variations in treatment and outcomes for patients with RAAA from 11 countries over 4 years.

MATERIALS AND METHODS

The Vascunet collaboration

Vascunet is an international collaboration of registries, consisting of national (Australia, Denmark, Hungary, Iceland, New Zealand, Norway, Sweden, Switzerland, UK), regional (Finland), and multi-centre (Germany) databases. The completeness of the participating registries was >90% for RAAA procedures performed in Denmark, Hungary, Iceland, Sweden, and Finland, 80% in New Zealand and Norway, and 68% in Australia.[18—21] The ascertainment rate in the UK was estimated at 73% for 2012—2014, but is uncertain for the 2 previous years.[22] The Swiss database includes patients operated for AAA in 129 public hospitals and represents approximately 85% of all open and 70% of all EVAR procedures in the country. The German data are based on approximately 130 certified vascular centres participating in the German Society for Vascular Surgery. A recent report by the same collaboration has documented outcomes following treatment of intact AAAs from the same database.[23]

Study design

Data on ruptured AAA repairs were collected from vascular registries for the 4-year period 2010—2013 from 11 countries. These were analysed overall, per country, per treatment modality (EVAR or OAR), for centre volume (divided into quintiles), and for centres that were either predominantly EVAR ($\geq$50% of RAAA repairs performed with EVAR; EVAR(p)) or predominantly OAR (OAR(p)).

Outcomes and variables

The primary outcome was peri-operative mortality, defined as either in hospital death (registries from Australia, Germany, Hungary, New Zealand, Norway, Switzerland, and United Kingdom) or death within 30 days of surgery (registries from Denmark, Finland, Iceland, and Sweden). Patients were also registered to a single hospital centre identification number. The covariates included for analysis were: age, gender, AAA diameter (cm), and the presence or absence of the following comorbidities: ischaemic heart disease, pulmonary disease, diabetes mellitus, and cerebrovascular disease.

The numbers (proportions) of missing data were as follows: peri-operative mortality, 47 (0.5%); age, 339 (3.6%); gender, 1232 (13.2%); hospital centre identification number, 1266 (13.6%); operative technique, 0 (0%); AAA diameter, 2013 (21.6%); ischaemic heart disease, 252 (2.7%); pulmonary disease, 1927 (20.7%); diabetes mellitus, 1405 (15.1%); cerebrovascular disease, 3313 (35.5%).

Statistical analysis

Continuous data are presented with mean values and 95% CIs, and compared with *t* tests. Rates are presented as percentages with 95% CIs. Missing data were handled by exclusion. Comparison of rates was performed using the chi-square test. Logistic regression models were performed to estimate the OR for peri-operative mortality for the included covariates. To correct for multiple testing, a p value of $<.01$ was regarded as significant. Finally, funnel plots were created using upper and lower CI (95% and 99.8%) from the calculated mean peri-operative mortalities, where

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