A meta-analysis of 50 years of ruptured abdominal aortic aneurysm repair
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Authors' objectives
To estimate the operative mortality of ruptured abdominal aortic aneurysm (RAAA) repair and to determine how it has changed over time.

Searching
MEDLINE (from January 1966 to November 2000) and EMBASE (from January 1980 to November 2000) were searched. The search terms were provided. In addition, the reference lists of retrieved articles were handsearched.

Study selection
Study designs of evaluations included in the review
Studies of all types of design were included, both prospective and retrospective observational studies, and experimental studies. Single case reports were excluded. Only articles published in English were included in the review.

Specific interventions included in the review
Articles reporting RAAA repair as the intervention of interest were included in the review. Articles were not restricted to any particular technique; transperitoneal, retroperitoneal and non-inlay were all included.

Participants included in the review
The participants were patients undergoing RAAA repair. Studies describing patients undergoing emergency or urgent repair of symptomatic non-ruptured AAA were excluded from the review, as were articles describing only selected groups of patients (e.g. octogenarians).

Outcomes assessed in the review
Articles were included if they reported the total number of patients undergoing RAAA and the total number of those who died.

How were decisions on the relevance of primary studies made?
The authors did not state how the papers were selected for review, or how many reviewers performed the selection.

Assessment of study quality
Individual study characteristics perceived as potentially related to the validity and quality of the particular included studies were examined according to published guidance (see Other Publications of Related Interest no.1). The authors recorded whether each study was a multicentre or single-centre study, whether the data on patient numbers had been obtained via the use of coded computerised records, and the level of evidence according to published criteria (see Other Publications of Related Interest no.2). The authors did not state how the papers were assessed for validity, or how many reviewers performed the validity assessment.

Data extraction
One author reviewed the included articles. For all studies, the total number of patients undergoing surgery, the total number of those who died, the mid-timepoint of the study (the date half-way through the study time period), and the definition of operative mortality (in-hospital or 30-day) were recorded. Where given, the number of patients who died during surgery, the average age and gender ratio of the study population, and the number of patients denied surgery were also recorded.

Methods of synthesis
How were the studies combined?
Separate meta-analyses were performed for operative and intra-operative mortality outcomes, using a random-effects model on a log odds outcome scale. The results were transformed to the proportion scale to aid interpretation.

Funnel plots were used to investigate the possible effects of publication bias. The trim and fill methods were used to assess how many studies might be missing and the impact of their inclusion on the analysis of both outcomes.

How were differences between studies investigated?
In the meta-analyses of operative and intra-operative mortality outcomes, the presence of heterogeneity was assessed using the standard chi-squared test.

In order to explain any between-study heterogeneity, meta-regression analyses were performed to explore the effect of time (using the covariate midpoint of study), patient age (using mean or median patient age), gender (using the covariate proportion of population female) and the number of patients denied surgery. A mixed model using the log odds outcome scale was used.

Sensitivity analyses were also carried out, with analyses stratified by measures of quality.

Results of the review
A total of 171 studies (n=21,523) were included in the analysis of overall operative mortality. Seventy-seven of these studies reported the intra-operative mortality rate, whilst 47 reported the mean or median age, 66 stated the gender ratio, and 28 reported the number of participants denied surgery.

Assessment of study quality: little difference was observed between the overall operative mortality rates for the 132 single-centre and the 39 multicentre studies. Five studies used coded computerised records and reported slightly lower mortality rates than those that did not use such records, though this was not statistically significant. Groups of studies classified using Blankensteijn's criteria (see Other Publications of Related Interest no.2) slightly differed from one another in mortality rates, though the pattern of these results was difficult to interpret.

The pooled operative mortality (171 studies) was 48% (95% confidence interval, CI: 46, 50), the pooled intra-operative mortality (77 studies) was 15% (95% CI: 13, 17), and the pooled post-operative mortality (77 studies) was 40% (95% CI: 37, 43). There was considerable heterogeneity within these pooled estimates (P<0.001 for all three).

Rate of operative mortality over time: including the mid-date of the study as a covariate in a meta-regression model suggested an approximately linear reduction in operative mortality over the 50 years of the practice covered by the literature (171 studies, P=0.001). This translated to a 3.5% reduction in mortality per 10 years over the analysis period.

Rate of intra-operative mortality over time: there was little evidence of an association between intra-operative mortality and study mid-date (slope coefficient 0.005, P=0.53).

Rate of post-operative mortality over time: there was little evidence of an association between post-operative mortality and study mid-date (slope coefficient -0.004, P=0.50).

Other results.
Where reported, there was no observed association between overall operative mortality and average age, the proportion of women in the study, or the number of patients denied surgery, nor was there any association between intra-operative mortality and average age. However, there was a positive association between intra-operative mortality and the proportion of women (32 studies, slope 4.450, P=0.02), and the proportion of women and average age (41 studies, P=0.02) (i.e. studies with a high proportion of women had a higher average age).

Seventy-seven studies reported average age and indicated that this has increased over time. A quadratic curve fitted the relationship, indicating that the average age has reached a plateau in the last 10 years.

A funnel plot of the 171 studies reporting overall operative mortality was symmetrical, indicating that publication bias
was unlikely. However, a funnel plot of the 77 studies reporting intra-operative mortality was highly asymmetrical, indicating that missing studies reported higher rates of intra-operative mortality. The method of trim and fill predicted 29 potentially missing studies which, if included, would increase the pooled estimate of intra-operative mortality to 20% (95% CI: 18, 23).

**Authors' conclusions**
Contrary to the conclusion of recent studies, this paper demonstrated a gradual reduction with time in the operative mortality rate of RAAA repair.

**CRD commentary**
This was a well-conducted meta-analysis of the literature on mortality associated with RAAA repair. The question was clearly stated and was supported by appropriate inclusion criteria. Multiple sources were searched to identify the relevant research (electronic databases and handsearching). Aspects of study quality were assessed using two sets of published criteria, and these were examined in the analysis. The methods used to synthesise the included study data were reported clearly and were appropriate, and they also investigated heterogeneity and publication bias. However, only English language studies were included, which may have contributed to the observed publication bias. The authors may have imposed this language restriction for a particular reason (e.g. to prevent the inclusion of reports from developing countries where operative mortality rates might differ considerably), although they did not state this. It was unclear how many reviewers were involved in the selection and quality assessment of the studies. If only one reviewer carried out these processes, there is the potential that some studies may have been missed or that some of those included may have been inaccurately coded. The authors reported their results clearly and their conclusions follow from the evidence presented in the meta-analysis.

**Implications of the review for practice and research**
Practice: The authors did not state any implications for practice.

Research: The authors stated that a prospective national audit might be the most useful approach to determine the predictors of mortality in RAAA. They recommended that future surgical research provides definitions of mortality and RAAA, and that all outcomes are reported in full.

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**Other publications of related interest**

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This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.