Relationship between travel time to the nearest hospital and survival from ruptured abdominal aortic aneurysms: record linkage study

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Abstract

Background There is currently a trend in Britain to concentrate specialist services in a smaller number of hospitals in order to improve outcomes. However, for rapidly life-threatening conditions such as ruptured abdominal aortic aneurysms (RAAAs), the resulting increased travel time to hospital might adversely affect survival. This study aimed to evaluate the relationship between travel time to the nearest hospital and survival from RAAAs in West Sussex.

Methods Information was collected regarding outcome, postcode, age, sex and diagnoses for all West Sussex residents who had a RAAA between January 1996 and September 1999, including admissions and deaths, wherever they occurred. Deprivation scores were calculated based on postcode. Potential travel time to the nearest hospital was calculated using “Microsoft AutoRoute Express” and its effect on outcome was analysed using multiple logistic regression.

Results After adjusting for age, sex, Townsend deprivation score and nearest hospital, the odds ratio for survival associated with a 10 min increase in potential travel time to the nearest hospital was 0.97 (0.88 unadjusted) (95 per cent confidence interval for adjusted odds ratio: 0.70 to 1.34; \( p = 0.86 \)).

Conclusion Several previous studies suggested better survival with longer distances travelled. They are likely to be biased by omission of community deaths. This methodologically better study found no such relationship between RAAA survival and travelling time to hospital in West Sussex, although confidence intervals were wide. This is particularly pertinent while there is a push to centralize vascular and other services in the United Kingdom.

Keywords: aneurysms, rupture, survival, time factors

Introduction

There is currently a trend in Britain to centralise specialist services. The hope is that increased throughput will increase surgeons’ expertise and improve outcomes, as suggested by two systematic reviews that found a positive relationship between volume and outcome in vascular surgery. However, the proposed centralisation of acute vascular surgery that was suggested by the Vascular Surgical Society of Great Britain and Ireland (VSS) in 1998 resulted in considerable debate. One of the issues raised was the impact that the associated increasing travel times to hospital might have on survival from ruptured aortic aneurysms (RAAs). This could be an issue with the centralisation of services for other rapidly life-threatening conditions too. The study described here was initiated following discussion on this issue during a review of acute vascular services in West Sussex. The aim was to investigate the relationship between travel time to hospital and survival from ruptured abdominal aortic aneurysms (RAAAs).
to the patient’s home. Outcome was divided into those who survived 2 or more days after admission to hospital and those who died before this. This is because the travel time to hospital was felt to be most likely to influence early survival as aortic aneurysm rupture is rapidly fatal without prompt intervention. Also included in the database for each patient was their age, sex and the Townsend deprivation score of the electoral ward in which they lived. The latter was based on 1991 Census data and was included because there was little reliable co-morbidity data on the database (because the patients were often very ill on admission). Deprivation scores are known to reflect overall health, at least at a population level. The Townsend score was used because of five deprivation scores tested in the multiple logistic regression model this one had the most effect on the coefficient for time to the nearest hospital. RAAA survival is known to be associated with age and sex of patients, hence their inclusion in the model.

The relationship between the individual variables and outcome was investigated by comparing the means (using \( t \)-tests and Mann–Witney \( U \)-tests) for continuous variables and by chi-squared tests for categorical variables. Multiple logistic regression was used to investigate the relationship between travel time to the nearest hospital and survival from RAAAs after adjusting for age, sex, Townsend deprivation score and nearest hospital. The odds ratio for survival associated with a 10 min increase in potential travel time to hospital was calculated.

### Results

934 deaths and 1037 admissions were found where routine data mentioned or included a code for “aortic aneurysm”. After merging deaths and admissions there were 1804 such cases. Those where the data recorded that the aneurysm had not ruptured or was not abdominal were deleted after checking the patient’s hospital records where there was doubt or ambiguity in the routine data. This left 515 cases of RAAAs. Examples of where the patient’s records were consulted are when the diagnostic code suggested a non-ruptured aneurysm and the procedure code suggested a ruptured one or where the site of the aneurysm was not specified.

Checks suggested that accuracy and completeness of the data were good. Of the 38 randomly chosen cases whose hospital records were checked all pertinent variables were correct except for slight discrepancies in dates of birth in two cases and admission and discharge dates in one. 37 of the 38 cases supplied at random by the surgeons from their own independent databases were included in our data set.

Of the 515 cases of RAAAs, 57 survived to discharge, 84 died after 2 or more days in hospital, 111 died less than 2 days after admission to hospital, 100 died in hospital before being formally admitted (those who survived for 2 or more days after admission versus those who died before this), 163 died before reaching hospital. For the two outcome categories used, the mean age of survivors was 75.2 years and for those who died it was 79.6 years (\( p < 0.001 \), \( t \)-test). The average Townsend deprivation score was –1.1 for survivors and –1.4 for those who died before being in hospital for 2 days (\( p = 0.2 \), Mann–Witney \( U \)-test). There was no significant relationship between outcome and gender (\( p = 0.1 \)) or nearest hospital (\( p = 0.8 \), chi-squared test,4 df\). However hospital of treatment (362 cases were treated in hospital) was significantly related to outcome (\( p < 0.01 \), 6 df). This variable was not used in the multiple logistic regression model because many patients died before reaching hospital. Nearest hospital was therefore used instead. Most (85 per cent) patients who reached hospital alive were treated at their nearest hospital.

The mean potential travel time to the nearest hospital was 14.2 min (standard deviation (SD) = 6.96 min) for the whole group. For those with a positive outcome it was 13.8 min (SD = 7.16) and for those with a negative outcome it was 14.4 min (SD = 6.89). This difference was not statistically significant (\( p = 0.95 \), \( t \)-test).

The result of the multiple logistic regression analysis is shown in Table 1. Having adjusted for age, sex, nearest hospital and Townsend deprivation score, the odds ratio for survival associated with a 10 min increase in potential travel time to hospital was 0.97 (95 per cent confidence interval 0.70–1.34). The unadjusted odds ratio was 0.88 (95 per cent confidence interval 0.67–1.16). Of the other variables in the model only age was statistically significantly related to outcome.

### Discussion

Many other studies have tried to investigate the relationship between distance to hospital and RAA survival. A systematic literature search revealed many relevant studies investigating this issue in different ways including assessments of the relationship between mortality and distance travelled to hospital, travel time to hospital, time from onset of symptoms to presentation, presentation to operation, direct presentation versus inter-hospital transfer, duration and severity of hypotension.

Some studies thus attempted to answer the question more directly than others. In none of these areas was the relationship with RAA survival clear. Studies tended to be small with wide confidence intervals. Results were in both directions and the size of relationships were usually small, as summarised in Table 2. Two meta-analyses performed also found no statistically significant relationship between the variable investigated and RAAA survival (Figs 1 and 2).

Many studies, including two of the three studies in Fig. 1 and four of the five studies in Fig. 2, suggested lower mortality for those who had to travel further to get to the hospital that performed the operative intervention. However, most of the studies are likely to suffer from selection bias as they do not include those who died in the community or pre-operatively. Thus patients who took a long time in transit or lived further from hospital were more likely to have died before reaching the treating hospital and not be included in the study. Only those who were relatively stable and thus survived transit would have been included. This may have masked a negative effect of
Previous studies did not adjust for potentially confounding variables. They also used actual travel times which could be biased by the fact that the transport of those who were more ill may have been expedited. This could explain the finding by some studies that a shorter travel time to hospital was associated with poorer survival. Increased severity and duration of hypotension did appear to be related to increased mortality, although the literature review did not attempt to retrieve all studies investigating this last issue.

A large proportion of patients do not reach hospital or operating theatres. For example, of 2666 cases in seven studies of RAAAs, 38 per cent died outside hospital and 28 per cent died in hospital before operative intervention. This could potentially have a large effect on the relationship found between RAAA mortality and travel time to hospital if those who lived further from hospital were more likely to die without being included in the studies. Thus the effect of selection bias in previous studies could be marked and could account for the frequent finding of lower mortality for those who travelled further to get to the treating hospital.

One study to avoid some of the flaws of previous studies by including all RAAA cases wherever they died. It also used potential rather than actual travel times to avoid bias due to more ill patients’ transport being expedited. After adjusting for other variables, we found no association between potential travel time to the nearest hospital and RAAA survival (odds ratio for 10 min increase in travel time = 0.97). However, the 95 per cent confidence interval was wide so that it is still possible that a larger study might find a significant association.

The design of this study involved several assumptions. The assumptions include that rupture occurred at home (likely in the elderly), home was assumed to be in the centre of the postcode sector, patients were transported to the nearest hospital (true in 85 per cent in this study), which surgeon operated is a confounding variable (likely to be true in 85 per cent of cases), and Townsend deprivation score is a confounding variable (likely to be true in 85 per cent of cases).

Other limitations included the relatively narrow range of travel times in West Sussex. Also, it was not possible to include all potentially confounding variables, such as co-morbidities, type of rupture (although dissecting, thoracic and emergency symptomatic non-ruptured aneurysms were excluded), and the surgeon who operated (likely to be true in 85 per cent of cases). To reduce the power of the study, we assumed that rupture occurred at home (likely in the elderly). Home was assumed to be in the centre of the postcode sector, patients were transported to the nearest hospital (true in 85 per cent in this study), which surgeon operated is a confounding variable (likely to be true in 85 per cent of cases), and Townsend deprivation score is a confounding variable (likely to be true in 85 per cent of cases).

The most likely effect of errors in these assumptions would have been to reduce the power of the study. The assumptions include that rupture occurred at home (likely in the elderly), home was assumed to be in the centre of the postcode sector, patients were transported to the nearest hospital (true in 85 per cent in this study), which surgeon operated is a confounding variable (likely to be true in 85 per cent of cases), and Townsend deprivation score is a confounding variable (likely to be true in 85 per cent of cases).

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Table 1 Summary of analysis of relationship between time to nearest hospital and survival from RAAAs for WS residents (January 1996–September 1999)

| Source: WSHA admissions and deaths databases as at March 2000, linked and cleaned. |
| "Microsoft® Autoroute Express™ 1997 Edition (Microsoft Corporation, Redmond, USA) was used to calculate travel times to hospital. |
| Townsend deprivation scores for electoral wards obtained from the “MIMAS” website and are based on 1991 Census data. |

<table>
<thead>
<tr>
<th>Description</th>
<th>All ruptured abdominal aortic aneurysm</th>
<th>Patients who survived for 2 or more days</th>
<th>Patients who died before 2 days</th>
<th>Unadjusted odds ratio for survival (95 per cent confidence interval)</th>
<th>P value</th>
<th>Adjusted odds ratio for survival (95 per cent confidence interval)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel time to nearest hospital in minutes Mean (SD)</td>
<td>14.2 (7.0)</td>
<td>13.8 (7.2)</td>
<td>14.4 (6.9)</td>
<td>0.88 (0.67–1.16) per 10 minutes</td>
<td>0.37</td>
<td>0.97 (0.79–1.18) per 10 minutes</td>
<td>0.86</td>
</tr>
<tr>
<td>Age in years Mean (SD)</td>
<td>78.4 (8.3)</td>
<td>75.2 (8.8)</td>
<td>79.6 (7.3)</td>
<td>0.94 (0.91–0.96) per 10 minutes</td>
<td>&lt;0.001</td>
<td>0.94 (0.91–0.96) per 10 minutes</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Townsend score Mean (SD)</td>
<td>-1.3 (2.3)</td>
<td>-1.1 (2.3)</td>
<td>-1.4 (2.3)</td>
<td>1.05 (0.97–1.15) per 10 minutes</td>
<td>0.23</td>
<td>1.03 (0.94–1.13) per 10 minutes</td>
<td>0.55</td>
</tr>
<tr>
<td>Sex Male</td>
<td>381</td>
<td>112</td>
<td>269</td>
<td>1.00 (reference)</td>
<td>0.08</td>
<td>1.00 (reference)</td>
<td>0.78</td>
</tr>
<tr>
<td>Female</td>
<td>134</td>
<td>29</td>
<td>105</td>
<td>0.66 (0.42–1.06) per 10 minutes</td>
<td>0.79</td>
<td>0.93 (0.57–1.53) per 10 minutes</td>
<td>0.55</td>
</tr>
<tr>
<td>Nearest hospital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worthing</td>
<td>225</td>
<td>61</td>
<td>164</td>
<td>1.00 (reference)</td>
<td>0.08</td>
<td>1.00 (reference)</td>
<td>0.78</td>
</tr>
<tr>
<td>Chichester</td>
<td>127</td>
<td>33</td>
<td>94</td>
<td>0.94 (0.58–1.55) per 10 minutes</td>
<td>1.01 (0.61–1.67) per 10 minutes</td>
<td>0.87 (0.52–1.47) per 10 minutes</td>
<td>0.79</td>
</tr>
<tr>
<td>Crawley</td>
<td>117</td>
<td>32</td>
<td>85</td>
<td>1.15 (0.55–2.41) per 10 minutes</td>
<td>2.69 (0.53–13.68) per 10 minutes</td>
<td>2.13 (0.41–11.13) per 10 minutes</td>
<td>0.79</td>
</tr>
<tr>
<td>Haywards Heath</td>
<td>40</td>
<td>12</td>
<td>28</td>
<td>1.28 (0.59–2.81) per 10 minutes</td>
<td>2.69 (0.53–13.68) per 10 minutes</td>
<td>2.13 (0.41–11.13) per 10 minutes</td>
<td>0.79</td>
</tr>
<tr>
<td>Portsmouth</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>2.69 (0.53–13.68) per 10 minutes</td>
<td>2.13 (0.41–11.13) per 10 minutes</td>
<td>0.79</td>
<td></td>
</tr>
</tbody>
</table>

Source: WSHA admissions and deaths databases as at March 2000, linked and cleaned.

"Microsoft® Autoroute Express™ 1997 Edition (Microsoft Corporation, Redmond, USA) was used to calculate travel times to hospital.

Townsend deprivation scores for electoral wards obtained from the "MIMAS" website and are based on 1991 Census data.
delays in treatment. These can be substantial\textsuperscript{10} and would also need to be tackled if time delays are important to outcome.

Despite these limitations this study had many strengths compared to previous studies. It avoided the selection bias that was likely to be present in hospital case-series by including all patients including those (approximately half) who died before admission to hospital. When comparing the results of this study to previous studies it was reassuring to find that the percentage of patients reaching hospital alive (48.9 per cent) was close to the 50 per cent suggested by the literature.\textsuperscript{3}

Unlike previous studies it attempted to control for potentially confounding factors by including only ruptures of the abdominal section of the aorta, excluding dissecting aneurysms and symptomatic non-ruptured aneurysms and including a factor linked to co-morbidities (the Townsend deprivation score). Although this is not likely to fully adjust for co-morbidities it should provide better adjustment than in previous studies. It also involved a design which was based on the use of routine data. This meant that it was possible to complete in a reasonably short period of time and with minimal resources and could be repeated elsewhere and for other conditions. Checks suggested that the accuracy and completeness of the routine data were reasonable. This is in keeping with findings of Samy \textit{et al}.\textsuperscript{29} who checked routine Scottish discharge data against records for 500 random AAA cases and found 97.8 per cent to be accurate.

\section*{Conclusion}

These findings, like previous studies, do not provide evidence against centralisation of acute vascular surgical services. However, the results should be extrapolated with caution outside the range of distances travelled in West Sussex. Outcomes should therefore be closely monitored after any centralisation of vascular services that takes place, locally in West Sussex or elsewhere.

The methods used in this study could usefully be applied to other conditions that are rapidly life-threatening and for which centralisation of services is taking place or where hospital Accident and Emergency departments are closing. An example might be gastrointestinal haemorrhage.

\begin{table}[h]
\centering
\caption{Summary of literature regarding the relationship between RAA mortality and distance / time to hospital}
\label{tab:literature_summary}
\begin{tabular}{|l|c|l|l|}
\hline
Factor investigated by study & Number of studies & Direction of result & Statistical significance (at $p < 0.05$) & Comments \\
\hline
Distance travelled to hospital\textsuperscript{6–9} & 4 & 3 studies suggest lower mortality for those travelling further, and one the opposite, but small effect. & None significant. Meta-analysis of 3 studies also found no statistically significant relationship (Fig. 1). & Wide confidence intervals; Possible bias due to omission of deaths outside the study hospital – those from further away are more likely to have died without being included in the studies. No adjustment for potentially confounding variables in 3 studies. \\
\hline
Time delays between symptom onset, presentation, and operation\textsuperscript{10–22} & 13 & 8 studies suggest lower mortality for patients with longer time intervals & Some (5) statistically significant (in direction of lower mortality with time intervals). Meta-analysis not possible. & Suggests that treatment of the more ill patients is expedited; Possible bias due to omission of deaths before operation / admission to hospital – those from further away are more likely to have died without being included in the studies. No adjustment for potentially confounding variables in most studies. \\
\hline
Inter-hospital transfer versus direct presentation\textsuperscript{7,9,18–20,23–25} & 8 & 5 studies suggested lower mortality for patients transferred to compared to those admitted directly to a larger unit. One suggested the opposite. & One of the 5 studies was statistically significant. Meta-analysis of 5 studies found no statistically significant relationship (Fig. 2). & Suggestion from studies and locally that only more stable patients are transferred. Those dying before operation were usually not included in the analysis. Numbers small. No adjustment for potentially confounding variables in most studies. \\
\hline
Severity and duration of hypotension\textsuperscript{6,8,9,11–13,15,17,18,20,24,26–28} & 14 but see comments & All suggest increased mortality with increased duration and / or severity of hypotension & 11 significant. Meta-analysis not appropriate. & The search strategy was not designed to find all such articles. Result not surprising. \\
\hline
\end{tabular}
\end{table}

N.B. some articles investigated more than one factor.
References


17 Ouriel K, Geary K, Green RM, Fiore W, Geary JE, DeWeese JA. Factors determining survival after ruptured aortic aneurysm:

Figure 1 Results of meta-analysis of three studies investigating the effects of distance travelled to hospital on RAA mortality. Odds ratios refer to the odds of dying for those travelling more than 10 miles to hospital compared to less than 10 miles. Chi-squared test for heterogeneity = 1.72, 2 df, p = 0.42, hence a fixed effects model was used.

Figure 2 Results of meta-analysis of five studies investigating the relationship between RAA mortality and inter-hospital transfer versus direct presentation to the larger hospital. Odds ratios refer to the odds of dying for those transferred between hospitals compared to those presenting directly to the larger hospital. Chi-squared test for heterogeneity = 3.6, 4 df, p = 0.61, hence a fixed effects model was used.


