Abstract

Background Our aim was to assess the geographical, social and hospital variation in carotid endarterectomy (CEA) over time in Scotland using routinely generated data, and to assess the outcome of CEA in terms of the 7 day case-fatality.

Methods A descriptive, retrospective study was carried out using computerized medical records at national level of all patients in Scotland who had a CEA during 1981–1996. Medical record linkage was used to identify the study population with the index event specified as CEA. The annual rate of CEA in Scotland and length of hospital stay for the procedure were determined. The geographical distribution of CEA, and the social circumstances of these CEA patients were described. Hospitals where CEAs were performed were evaluated in terms of high-, medium- and low-volume hospitals.

Results A total of 2892 CEA patients were identified for the period 1981–1996. The CEA rate increased from 1.2/100 000 (1989) to 8.6/100 000 (1996) with a maximum of 19/100 000 in Tayside Health Board (1994). Most of the CEAs in Scotland after the publication of the trials were in a small number of ‘high’-volume hospitals (>50 operations/year). There was no gender inequality in the provision of CEA in Scotland but substantial social and regional variation was observed. The 7 day operative mortality of 1.5 per cent was higher than that observed in the randomized trials.

Conclusions CEA in Scotland is performed now at about the expected rate, but there are still probably too many operations being carried out in low-volume hospitals. Length of stay has decreased over time. The operative mortality, however, was higher than in the randomized trials.

Keywords: carotid endarterectomy, record linked data, historical, utilization, social, survival

Introduction

In the last decade there has been a marked increase in the number of carotid endarterectomies (CEAs) performed in one centre in Scotland. A similar trend within Great Britain and Ireland has been documented, as well as in other countries. This increase coincided to a large degree with the publication of the early results from the two large randomized controlled clinical trials (RCTs) in 1991. Guidelines on the management of patients with carotid stenosis based on these trials have subsequently been published. A six-fold increase in the number of CEAs in Scotland has been described for the period 1989–1995, this study also highlighting the geographical inequality in provision of CEA, with the rate per 100 000 population varying between zero (two regions) and 19 (one region). Despite the increase in the number of CEAs, and the geographical inequality, the social dimensions associated with CEA and variation in uptake of CEA by hospital have not been assessed in Scotland. Although the database of the National Health Service (NHIS) in Scotland incorporates Healthcare Resource Groups (HRGs) based on the International Classification of Diseases (ICD), and on the surgical operations and procedures of the Office of Population Censuses and Surveys (OPCS; now the Office for National Statistics) classification, HRG costs for Scotland are not available. Fortunately, the length of hospitalization for the procedure is routinely collected in this national database, and so can be used to at least estimate the cost of carotid endarterectomy. Also, mortality statistics are linked with the Government Statistical Services from the Registrar General Scotland. Making use of these nationally collected and linked data, the objective of this study was to describe the geographical, social and hospital variation in CEA over time in Scotland, and to assess the outcome of CEA in terms of the 7 day post-operative case-fatality.

Methods

Description of the study population

The study population included all the patients in Scotland who had a CEA during the period 1981–1996 (Scottish ISD-CEA dataset). The patients were identified by means of the Scottish ISD-CEA dataset.
entitled carotid endarterectomy. This database is linked to the Registrar General’s death records and therefore contains information on any deaths occurring both in and out of hospital for the Scottish population. The codes from the Tabular List of the classification of surgical operations and procedures of the OPCS were used to identify these patients. OPCS 3 codes were in use during the period 1981–1988 and the code 082.8 for operations of arteries in the neck (NEC, endarterectomy). The OPCS 4 coding system came into effect in 1989, is still in use, and includes the codes L29.4 (endarterectomy of carotid artery and patch repair of carotid artery) and L29.5 (endarterectomy of carotid artery NEC). The routinely collected variables extracted from the ISD database for patients who had a CEA included demographic data, the operation code, postcode, length of hospital stay, and date and cause of death by ICD 9 code.

Defining the datasets
The study population in the main dataset, the Scottish ISD-CEA dataset, was divided into three almost equal 5 year periods, to allow comparisons over time. The early period included the five years from January 1981 to December 1985. The middle period, January 1986–June 1991, referred to the five and a half years before the publication of the two large RCTs. The recent period, July 1991–December 1996, referred to the five and a half years after the publication of the findings from those trials.

Defining the analyses
Normal probability plots were used to assess any departure from normality. All categorical variables were compared by means of $\chi^2$ statistics. All $p$ values reported are two-sided. The inter-quartile ranges were defined as $Q_{0.25}$–$Q_{0.75}$.

Geographical variation
The geographical variation of CEA was investigated according to either health board of residence or health board of operation, using routinely collected variables in the dataset, and extends a previous report.

Volume of carotid endarterectomies per hospital
The hospitals where carotid endarterectomies were performed were arbitrarily grouped into low-volume hospitals, performing between one and 12 CEAs per year, medium-volume hospitals (13–49 CEAs per year) and high-volume hospitals with more than 50 CEAs per year. The number of CEAs per surgeon was not investigated.

Social and economic circumstances
These were assessed by applying area deprivation scores of the Carstairs index, based on the 1991 Census information for Scotland, to the postcode sectors for the CEA patients.

Results
Baseline characteristics of the study population (Table 1)
A total of 2892 carotid endarterectomies were performed over the 16 year study period from January 1981 to December 1996. When the Scottish ISD-CEA dataset was divided into the three periods, 336 (19 per cent) CEAs were performed during the early period, 476 (16 per cent) during the middle period and the majority of the operations 1880 (65 per cent) during the recent period. There was a normal age distribution, with a mean age of 64.1 years and standard deviation 8.8. Considering the entire dataset, the majority of patients (1413; 49 per cent) were 50–65 years old and 1268 (44 per cent) were between the ages of 66 and 80 years. Of these CEAs operations, 1719 (59 per cent) were performed in men and 1173 (41 per cent) in women. This 3:2 ratio was observed over the three time periods.

Frequency of the procedure over the 16 year study period
Only 98 operations were performed in 1981 (Figure 1). There was then a gradual increase until 1985, when 121 patients had a CEA. A gradual decline was observed from 1986 to 1989, with a minimum of 60 operations in 1989. From 1990 a steep increase in the number of carotid endarterectomies occurred, with 68 operations in 1990 to a total of 443 procedures in 1996. This represents more than a six-fold increase. The CEA rate per 100 000 of the Scottish population has increased steadily from an all-time low of 1.2 per 100 000 (1989) to a maximum of 8.6 per 100 000 (1996).

Geographical distribution of carotid endarterectomy
The health board resident population ranged from 19 870 in Orkney to a maximum of about 912 500 in Greater Glasgow. All 2892 carotid procedures performed over the 16 year study period could be linked to a specific health board of residence. The frequency varied from a minimum of two operations in Orkney health board to a maximum number of 626 operations in the Greater Glasgow health board. The CEA rate per 100 000

Table 1: Demographic characteristics of carotid endarterectomy patients in Scotland: 1981–1996

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The entire period: 1981–1996 (n = 2892)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>1719 (59%)</td>
<td>1173 (41%)</td>
<td>2892</td>
</tr>
<tr>
<td>Mean age (SD)</td>
<td>64 (8.7)</td>
<td>64 (8.8)</td>
<td>64 (8.8)</td>
</tr>
<tr>
<td>Number</td>
<td>324 (60%)</td>
<td>212 (40%)</td>
<td>536</td>
</tr>
<tr>
<td>Mean age (SD)</td>
<td>61 (9.5)</td>
<td>61 (8.2)</td>
<td>61 (8.1)</td>
</tr>
<tr>
<td><strong>The middle period: 1986–June 1991 (n = 476)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>284 (59%)</td>
<td>192 (40%)</td>
<td>476</td>
</tr>
<tr>
<td>Mean age (SD)</td>
<td>61 (7.5)</td>
<td>61 (8.7)</td>
<td>61 (8.1)</td>
</tr>
<tr>
<td><strong>The recent period: July 1991–1996 (n = 1880)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>1112 (59%)</td>
<td>768 (41%)</td>
<td>1880</td>
</tr>
<tr>
<td>Mean age (SD)</td>
<td>66 (8.2)</td>
<td>66 (8.5)</td>
<td>66 (8.3)</td>
</tr>
</tbody>
</table>
population by health board for the years 1986–1996 varied from a low of 0.9 in Orkney to a high of 10.3 in Tayside (Figure 2). The CEA rate has been consistently higher in Tayside compared with the other 14 health boards, ranging from 6.0/100 000 in 1981 to 19/100 000 in 1994. Similar increases were observed in the health boards of Argyll & Clyde, Ayrshire & Arran, Dumfries & Galloway, Grampian and Greater Glasgow. The CEA rate per 100 000 residents in the Lothian health board has remained relatively stable, varying between 2.1/100 000 (1984) and 3.9/100 000 (1996).

Over the 16 years, the operation was performed in 20 hospitals in 11 of the 15 health boards in Scotland. Using the hospitals where the operations between 1981 and 1985 were performed as reference to classify all the procedures with a specific health board of operation, the maximum number of 1193 (41.2 per cent) operations were associated with the Greater Glasgow health board and the minimum of four (0.14 per cent) CEs with the health board of the Western Isles. Between 1981 and June 1991 CEA was performed in nine (Greater Glasgow, Tayside, Lothian, Grampian, Dumfries & Galloway, Lanarkshire, Highland, Forth Valley and Western Isles) of the 15 health Boards, and since July 1991 in two additional health boards, Ayrshire & Arran and Argyll & Clyde. The operation was never performed in the four health boards of the Borders, Fife, Orkney and Shetland.

**Hospital volume**

For the period 1992–1996, a minimum of three operations was performed in the Western Isles Hospital, Stornoway and a maximum of 368 in the Western Infirmary Glasgow. Nine of the 20 hospitals performed between 46 and 368 CEs over this 5 year period. Only three hospitals (Royal Infirmary Edinburgh, Ninewells Dundee and Western Infirmary Glasgow) performed more than 45 CEs per year over three consecutive years (1994–1996). Classifying the hospitals into low, medium and high volume it was found that just about a quarter of all hospitals performing CEs were high-volume hospitals. In 1996, eight low-volume hospitals were still performing CEs, but the
majority of CEAs (66 per cent) were performed in four hospitals considered to be high volume (Table 2). This trend was also observed for 1992–1996.

Social distribution of carotid endarterectomy according to the Carstairs deprivation scale

The distribution of deprivation scores of patients having CEA in Scotland was dissimilar to that of the overall population (χ² = p 0.001). Based on 1991 Census data, the observed number of CEAs for categories 1–3 (least deprived) was in keeping with the number of CEAs expected. Fewer CEAs were performed in categories 4 and 5, but more than the expected number of CEAs was performed in categories 6 and 7 (most deprived). The CEA rate varied from 42/100 000 per annum (p.a.) in category 5 to 98/100 000 in category 6 (Table 3). There was no difference between men and women and between the different age categories investigated.

Length of hospital stay

The mean number of days in hospital was eight with a standard deviation of 20.7. The IQR0.25–0.75 was 4–8 days with a median length of stay of 5 days. It was not possible to distinguish between type of hospital stay (i.e. intensive therapy, high-dependence or general ward stay) from the routinely collected data. The overall length of hospital stay decreased from 10 days during the period 1981–1985 to 6 days for the period 1991–1996.

Case fatality

The 7 day operative mortality observed for this cohort was 1.5 per cent. Of the 44 deaths during the first 7 days after CEA, the cause of death for 30 patients was recorded as cerebrovascular (ICD 9 codes 430–438).

Discussion

The CEA rate in Scotland has increased steadily from a low of 1.2 per 100 000 in 1989 to 8.6 per 100 000 in 1996. This study confirms that the frequency with which this operation is performed has changed almost certainly as result of published clinical evidence from the two large randomized controlled trials demonstrating the efficacy of CEA. The CEA rate in Scotland in 1993 of 5.9/100 000 was higher than the rate of 3.5/100 000 for England and Wales, and considerably higher than the 0.7/100 000 observed in Northern Ireland.21 Significant regional variation in provision by health board of residence22 has again been highlighted, varying from zero in two health boards to 19 per 100 000 population for one specific year. This variation in rates between the health boards might indicate over- or under-utilization as the total number of CEAs performed per year is about the expected number for the Scottish population. Of the 15 health boards, six had CEA rates in 1996 that were similar to the national rate, two had considerably higher rates and seven had much lower rates.

| Table 2 | The number of carotid endarterectomies in Scotland, 1992–1996, classified according to hospital volume |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Low-volume hospitals | 28 | 43 | 35 | 42 | 49 | 197 (11%)       |
| Medium-volume hospitals | 170 | 147 | 158 | 107 | 100 | 682 (38%)       |
| High-volume hospitals | 67 | 111 | 204 | 253 | 294 | 929 (51%)       |
| Total carotid endarterectomies | 265 | 301 | 397 | 402 | 443 | 1808            |


| Table 3 | Carotid endarterectomy (CEA) study population 1981–1996 according to Carstairs index of deprivation |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Deprivation category | Estimated population 1991 Census | Social distribution Scottish population (%) | CEA patients 1981–1996 | Social distribution CEA patients (%) | CEA rate per 100 000 population over 16 year period |
| 1: most affluent | 255 350 | 5 | 160 | 6 | 63 |
| 2               | 510 700 | 10 | 309 | 11 | 61 |
| 3               | 1 021 400 | 20 | 572 | 20 | 56 |
| 4               | 1 532 100 | 30 | 682 | 24 | 44 |
| 5               | 1 021 400 | 20 | 430 | 15 | 42 |
| 6               | 510 700 | 10 | 498 | 17 | 98 |
| 7: most deprived | 255 350 | 5 | 206 | 7 | 81 |
| Missing         | – | – | 35 | 1 | – |
| Total           | 5 107 000 | 100 | 2892 | 100 | 57 |
Although many CEAs were still performed mainly in low- and medium-volume hospitals after the publication of the randomized controlled trials, just over half the procedures were carried out in a small number of hospitals performing more than 50 CEAs per year. This suggests that guidelines might not be implemented in practice or that these recommendations might be inappropriate for the Scottish population.\textsuperscript{3–11} Tayside hospitals had a considerably higher CEA rate than the other hospitals. We can only speculate that at the time of this study period, the referral of patients for consultant assessment was quicker and hence there were more suitable candidates for the procedure, or it might be that vascular surgeons in Tayside had a keen interest in carotid stenosis and performing CEA.

The mean age for this procedure increased from 61 years during the early period to 66 years during the most recent period. This finding was not surprising, as the middle period and recent period mirror the use of CEA after the publication of the large randomized controlled trials in the early 1990s during which the procedure has become more established and so extended into older patients.

We have demonstrated the reduction in the use of health care resources based solely on length of hospital stay. There was no deficit of CEA in deprived areas; rather, the reverse was seen, with the rate being substantially higher in areas associated with social deprivation. This finding might reflect on the overall health status of people living in areas of social deprivation: they have more vascular disease, which necessitates more health care interventions. It might be argued that the Scottish database used in this investigation does not capture the activity of CEA in the private sector and that this finding is therefore dubious. Data are not routinely collected on CEA activity in the private sector, but it appears that the volume of this procedure in the private sector is relatively low, and is unlikely to influence the finding on social deprivation.

The 30 day case-fatality rate of 2.3 per cent for this cohort was considerably higher than the rate of 1.1 per cent obtained from the analysis of pooled individual patient data of all randomized controlled trials of carotid endarterectomy for symptomatic carotid stenosis.\textsuperscript{22}

Conclusions

In the context of the Scottish population the number of carotid endarterectomies is nowadays roughly within the range (450–700) we would expect, based on suggestions from the Association of British Neurologists and estimates using the incidence of transient ischaemic attack and of minor non-disabling strokes.\textsuperscript{23,24} Although many so-called low-volume hospitals still perform CEAs in Scotland, the majority of operations are performed in a small number of hospitals classified as high volume. This demonstrates a very low CEA activity in the majority of hospitals but that still the recommendations from guidelines of about 50 CEAs per surgeon per year are not being implemented, or alternatively might not be appropriate for Scotland.

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References


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