Major geographical variations in elective coronary revascularization by stents or surgery in England

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Abstract

OBJECTIVES: Revascularization in stable coronary artery disease (CAD) can be achieved through percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG) depending on the anatomical pattern of CAD, comorbidities and patient preference. Recent studies in the USA, Canada and Australia show marked local variation in the PCI/CABG ratio that is unexplained by patient-related factors. This current study assesses the geographical variation in elective coronary revascularization interventions across England and discusses its appropriateness.

METHODS: The rates and actual procedure numbers of total CABG, total PCIs and elective PCIs were collated for each of 151 primary care trusts (PCTs). The ‘elective PCI/total CABG ratio’ was taken as an indicator of elective coronary revascularization practices. The Index of Multiple Deprivation (IMD) for PCTs was taken as a marker of deprivation.

RESULTS: In 2010/2011, the degree of variation in elective PCI/total CABG ratios across 151 PCTs in England was >13-fold (min = 0.36, max = 4.74, median = 1.19, interquartile range = 0.98, 1.73). The ratio was not correlated to the IMD 2010 rank of the PCTs (Spearman’s ρ = 0.08, P = 0.36) and was not explained by the volume of interventions performed.

CONCLUSIONS: Despite clear evidence-based guidelines for intervention, marked geographical variation in elective coronary revascularization practices also exists in England. This variation is unexplained by procedure volume or deprivation, suggesting the contribution of unwarranted influences which may include practitioner preference. To reduce this level of unwarranted variation, we suggest that all interventions should be underpinned by internationally recognized guidelines or approved by a multidisciplinary team approach (The Heart Team).

Keywords: Coronary artery bypass graft • Percutaneous coronary intervention • Stent • Geographical variation • Unwarranted variation

OBJECTIVES

Revascularization, in addition to optimal medical therapy, may be indicated in stable severe coronary artery disease (CAD) on symptomatic and/or prognostic grounds [1]. Revascularization can be achieved through two interventions: percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG). The more appropriate procedure for a specific patient is influenced by a number of factors including the patient’s age, pattern of CAD, associated comorbidities and patient preferences [1]. Traditionally, the total PCI/CABG ratio has been near 1. However, over the last decade, total PCI rates have increased every year, while the use of CABG has declined, leaving the current ratio closer to 5 [2]. One legitimate contributor to this trend is the increased use of primary PCI as an emergency therapy in ST segment-elevation myocardial infarction for which CABG is not usually indicated. However, other potential drivers for this change include the use of ad hoc PCI during elective angiography (where stenting is performed at the same time as a diagnostic angiogram) and the increasing use of PCI in patients with more complex disease patterns of CAD, such as multivessel and left main stem disease, for which CABG has traditionally been recommended [3, 4]. The latter use is controversial as, for most patients in these groups, CABG is still clinically superior with reduced long-term mortality, myocardial infarction and less need for repeat revascularization [5].

The latest guidelines on myocardial revascularization were published jointly by the European Society of Cardiology (ESC) and European Association for Cardio-Thoracic Surgery (EACTS) in 2010 [1]. Using the SYNTAX scoring system to assess the overall anatomical severity of CAD [6], CABG was shown to have a stronger evidence base than PCI in seven of eight anatomical patterns of CAD, and in many situations has a survival advantage as well as a marked reduction in the need for repeat intervention. However, as guidelines by definition are not mandatory, the intervention

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recommended and/or offered to the patient may be susceptible to other influences including physician preference [7, 8]. That possibility is compounded by strong evidence that the majority of patients undergoing elective PCI do not understand the main reason for the intervention and erroneously assume that it will prolong life and reduce the risk of further myocardial infarctions [9].

Recent studies in Canada [10] and Australia [11] show that the PCI/CABG ratio is highly variable even between neighbouring regions. It has been suggested that this is only partly related to patient demographics and incidence of disease (warranted variation) and that much of it is accounted for by variation in practitioner choice, resource distribution and potentially perverse incentives (unwarranted variation). Thus, patients in certain regions may be less likely to receive the optimal treatment. With the ‘universality’ of the National Health Service (NHS), there is an expectation that the magnitude and quality of intervention is tailored to match the needs of patients regardless of location. This study investigates the magnitude of geographical variation in nonemergency (elective) coronary revascularization practices throughout England.

**METHODS**

**Data sources and collection**

Data on the relevant procedural rates were available from the National Cardiovascular Disease Profiles stored electronically with South East Public Health Observatory (SEPHO) (http://www.sepho.org.uk/NationalCVD/NationalCVDProfiles.aspx). These profiles summarize the latest cardiovascular intervention rates detailed in the Hospital Episode Statistics (HES) dataset published by the NHS Information Centre for Health and Social Care. For each of 151 primary care trusts (PCTs) in England, we obtained the 2010/2011 procedural rates, per 100,000 population, for total CABG (HES Codes K40-K46), total PCI (HES Codes K49-50, K75) and elective PCI. As there are no data detailing separately the rates of elective and urgent CABG, we calculated elective PCI/total CABG ratios for each individual PCT in 2010/2011 as our indicator of elective coronary revascularization practices. Corresponding numbers of procedures were also extracted.

Data on the latest Index of Multiple Deprivation (IMD 2010) for the same PCTs were obtained from the Department of Communities and Local Government. PCTs were the large administrative bodies which held their own budgets and set their own priorities for the provision of healthcare services within the NHS during the time period which the data in this study refers to. The IMD covers seven distinct domains: income, employment, health deprivation and disability, education skills and training, barriers to housing services, crime and the living environment. IMD 2010 is then used to rank every lower layer super output area (LSOA) in England. LSOAs are the smallest geographical unit within a PCT for which most indicators are available and are non-overlapping between PCTs, enabling sensitive identification of pockets of deprivation. The data we accessed ranked the PCTs in England from most deprived (1) to least deprived (151) based on the average of the LSOA ranks within each PCT (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/15242/1981203.xls).

**Statistical analysis**

Our first aim was to assess the degree of variation in elective coronary revascularization practice in different PCTs across England using the elective PCI/total CABG ratio as our indicator. We analysed the datasets for individual PCTs and calculated ratios of elective PCI/total CABG rates. We then examined the variation using the median, interquartile range (IQR) and total range.

Our second aim was to determine whether the variation in the choice of revascularization seen was associated with the volume of procedures performed by a PCT. We used a funnel plot to examine the variation across PCTs in the proportion of procedures that were CABG. These plots depict observed variability in relation to expected random variation with reference to the volume of procedures. The plot depicts limits that would include 95% or 99.8% of PCTs if there was only random variation. The ratios of actual numbers used for the funnel plot differ only slightly from the ratios of rates used in the analyses of rates, which are age-standardized.

We further sought to identify whether variation was related to the degree of deprivation in individual PCTs. As the data were not normally distributed, we assessed the correlation of procedural rates and the elective PCI/total CABG ratio with the IMD 2010 rank in 151 PCTs using Spearman’s rank correlation coefficient. A P-value of <0.05 was taken as being statistically significant. We used Stata 12.0 and GraphPad Prism 5 for statistical analysis.

**RESULTS**

Our results show marked variation in the coronary revascularization practices across the 151 PCTs studied (Table 1). The mean of the combined total CABG and elective PCI procedures per PCT was 297 (range 75–1213). The maximal difference in elective PCI/total CABG ratios was a 13-fold difference between North Tyneside (4.74) and Darlington (0.36); two areas that are geographically very close to each other. Seventeen PCTs (11%) had elective PCI/total CABG ratios either more than double or less than half the median ratio in England (Fig. 1).

To determine whether the PCTs with extreme elective PCI/total CABG ratios also had lower total procedure rates, we plotted the ratios against the combined rates of elective PCI and total CABG procedures per 100,000 population, an indicator of total elective coronary revascularization procedures (Fig. 1). Figure 1 shows that the PCTs with extreme ratios were not those regions with low procedure volumes. Figure 2 shows the variation across PCTs in the

<p>| Table 1: Frequency distribution of elective PCI/total CABG ratios across 151 PCTs in England (2010/2011) |
|--------------------------------------------------|------------------|------------------|</p>
<table>
<thead>
<tr>
<th>Elective PCI/total CABG ratio</th>
<th>Number of PCTs</th>
<th>Percentage of total PCTs</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>41</td>
<td>27.2</td>
</tr>
<tr>
<td>1–1.99</td>
<td>88</td>
<td>58.3</td>
</tr>
<tr>
<td>2–2.99</td>
<td>14</td>
<td>9.3</td>
</tr>
<tr>
<td>3–3.99</td>
<td>6</td>
<td>4.0</td>
</tr>
<tr>
<td>&gt;4</td>
<td>2</td>
<td>1.3</td>
</tr>
<tr>
<td>Total = 151</td>
<td>Total = 100</td>
<td></td>
</tr>
</tbody>
</table>

PCI: percutaneous coronary intervention; PCT: primary care trust; CABG: coronary artery bypass grafting.
proportion of procedures that were CABG in relation to the combined number of total CABG and elective PCI performed. It is clear that the variability is considerably greater than can be explained by chance alone.

We also analysed the variation in individual procedure rates. For total PCI procedures (elective and emergency), there were no PCTs that performed either less than half or more than double the median rate of 104.2 per 100 000 population. For total CABG, only 2 of 151 PCTs (1.3%) performed less than half or more than double the median rate of 29.8 per 100 000 population. However, when we analysed elective PCI rates, we found that 15 of 151 PCTs (9.9%) performed either less than half or more than double the median rate of 39.6 per 100 000 population.

We examined whether the coronary revascularization practices were correlated to the level of deprivation within a PCT (Table 2). As CABG is traditionally preferred to elective PCI in more severe CAD, it may be expected that in regions with higher levels of deprivation (an IMD 2010 rank closer to 1), where the severity of CAD is also usually higher, a lower elective PCI/total CABG ratio might be anticipated. Thus, if the marked variation in elective PCI/total CABG ratios identified is warranted, we would expect to find a negative correlation between the ratio and the IMD 2010 rank. Total PCI rates were negatively correlated with the IMD 2010 rank, suggesting that where deprivation is greater, there is indeed a tendency for higher total PCI rates. CABG rates were also negatively correlated with IMD 2010 rank, again suggesting that where deprivation is greater, there is also a tendency to perform higher rates of CABG. In contrast, elective PCI rates showed no significant correlation with IMD 2010 rank. Overall, no correlation was found between elective PCI/total CABG ratios and IMD 2010 rank, suggesting that there is no association between the level of deprivation of a PCT and the utilization of elective revascularization practices (Fig. 3).

CONCLUSIONS

Summary of main findings

We believe that our study is the first to quantify and seek an explanation for the variation in the elective PCI/total CABG ratios in England in 2010/2011. There was marked variation in coronary revascularization practices among English PCTs which is not explained by overall procedure volume or deprivation. Whereas only 2 of 151 PCTs (1.3%) performed less than half or more than double the median total CABG rate, 15 of 151 PCTs (9.9%) performed either less than half or more than double the median rate of elective PCI. Although, as expected, CABG rates across PCTs are correlated with the level of deprivation, there was no correlation...
with elective PCI rates. While some variation in elective PCI/total CABG ratios may reflect genuine differences in the need for the two interventions, it may alternatively represent inefficiencies in the utilization of resources in different regions. Given the occurrence of these variations globally, and the current climate of financial austerity, it has become increasingly important to critically appraise the allocation of scarce resources.

**Meaning of the findings**

Distinct populations differ in their demographics (age, sex and ethnicity), severity of CAD, associated comorbidities and patient preferences. As such, some variability in elective PCI/total CABG ratios is expected when optimizing patient management. However, the magnitude of variation across PCTs strongly suggests the influence of other, unwarranted factors. In particular, the lack of correlation between the index of deprivation and the mode of revascularization suggests the absence of significant socioeconomic factors that may underlie such wide variation. Our results are also consistent with a previous study by The King’s Fund which demonstrated no association between the level of deprivation and elective PCI rates [12].

Unwanted variation may arise from inequalities in supply or demand. On the supply side, the PCI/CABG ratio may be influenced by the number of catheterization laboratories and cardiothoracic centers, the distance to nearest centre and the lengths of waiting lists for the different procedures. This concept of supply-driven demand is underpinned by numerous studies that indicate that referral practices are influenced greatly by ease of access to resources [12].

Despite internationally recognized guidelines outlining the evidence base for recommendations for PCI and CABG in differing anatomical patterns of CAD [1], individual practitioners can, however, ignore these recommendations according to their own personal preferences. This scenario is possibly compounded by the fact that PCI may be performed ‘ad hoc’, i.e. immediately after coronary angiography, when the patient may have had no opportunity to discuss possible surgical options with a cardiac surgeon. The fact that patient choice (demand) for PCI and CABG is greatly influenced by the preferences and actions of individual practitioners is increasingly acknowledged [1]. This situation is potentially further complicated by physicians being unconsciously influenced by overt or subtle ‘perverse’ incentives to pursue interventions in which they are skilled even if not necessarily optimum therapy [7, 8, 12]. Indeed, several studies have recently reported that not only may the documented indications for PCI be uncertain or inappropriate in almost half of all elective patients [12], but also as many as one-third of patients with Class I indications for CABG are still submitted to PCI instead [7]. Finally, the fact that as many as 70% of patients undergoing elective PCI mistakenly believe that it is to improve life expectancy and prevent further myocardial infarction [9] raises serious concerns about the nature and method of advice given to patients and indeed the whole consent process.

While guidelines remain optional, unwarranted heterogeneity in referral patterns and clinical decisions are likely to persist. Consequently, we recommend that elective intervention in an individual patient should be under the auspices of a multidisciplinary team rather than being made by an individual practitioner, especially if the proposed intervention appears at odds with guideline recommendations. Local protocols for interventions, based on guidelines, can avoid the need for discussion of every intervention in which they are skilled even if not necessarily optimum therapy [7, 8, 12]. Indeed, several studies have recently reported that not only may the documented indications for PCI be uncertain or inappropriate in almost half of all elective patients [12], but also as many as one-third of patients with Class I indications for CABG are still submitted to PCI instead [7]. Finally, the fact that as many as 70% of patients undergoing elective PCI mistakenly believe that it is to improve life expectancy and prevent further myocardial infarction [9] raises serious concerns about the nature and method of advice given to patients and indeed the whole consent process.

While guidelines remain optional, unwarranted heterogeneity in referral patterns and clinical decisions are likely to persist. Consequently, we recommend that elective intervention in an individual patient should be under the auspices of a multidisciplinary team rather than being made by an individual practitioner, especially if the proposed intervention appears at odds with guideline recommendations. Local protocols for interventions, based on guidelines, can avoid the need for discussion of every individual patient. This ‘Heart Team’ should consist of at least one noninvasive cardiologist, one interventional cardiologist and one cardiothoracic surgeon, and their recommendations should be firmly based on recognized authoritative guidelines taking into account patient comorbidities and preferences, and documented as such. Furthermore, the patient should maintain an active role in the decision-making process by being adequately informed and given the necessary time to assimilate this information. Finally, to ensure optimal use of ever increasingly limited budgets, payers
should be able to justify their elective PCI/CABG ratios and should consider not reimbursing elective interventions that have not been agreed by a Heart Team.

**Weaknesses of the current study**

A limitation of this study is the absence of data detailing the number of elective CABG procedures in different PCTs; as such, our calculated ratios include urgent and emergency CABG. Recent studies suggest that nonelective CABG procedures account for up to 37% of the total CABG volume [13]. Unfortunately, HES data do not differentiate between elective and nonelective CABG procedures although there is no evidence that the authors are aware of to suggest that the rates of urgent and emergency CABG vary across the UK. It would be useful to determine the variation in revascularization practices done on a purely elective basis; this would be best achieved by each healthcare denomination independently assessing individual patient records. The use of HES data ignores the provision of coronary revascularization by the private sector where the PCI/CABG ratio may be further influenced by financial incentives. Another limitation is the lack of individual patient data. It would be particularly valuable to analyse the choice of revascularization procedure according to the severity of CAD using an established scoring modality (e.g. SYNTAX) to quantify the degree of unwarranted variation more precisely.

**Recommendations**

We recommend that three underlying principles should be adopted in order to maximize the equitable allocation of scarce resources: a multidisciplinary team approach to coronary revascularization, ‘mandatory’ adoption of guidelines and financial accountability.

**Conflict of interest:** Sheharyar S. Baig and Douglas G. Altman report no conflicts of interest. David P. Taggart is a cardiac surgeon.

**REFERENCES**


