Percutaneous coronary intervention in the elderly: Changes in case-mix and peri-procedural outcomes in 31,758 patients treated between 2000 and 2007.

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Abstract

Background

The elderly account for an increasing proportion of the population and have a high prevalence of coronary heart disease. Percutaneous coronary intervention (PCI) is the most common method of revascularisation in the elderly. We examined whether the risk of peri-procedural complications following PCI was higher among elderly (≥75 years) patients and whether it has changed over time.

Methods and Results

The Scottish Coronary Revascularisation Register was used to undertake a retrospective cohort study on all 31,758 patients undergoing non-emergency PCI in Scotland between April 2000 and March 2007 inclusive. There was an increase in the number and percentage of PCIs undertaken in elderly patients, from 196 (8.7%) in 2000 to 752 (13.9%) in 2007. Compared with younger patients, the elderly were more likely to have multi-vessel disease, multiple comorbidity and a past history of myocardial infarction or coronary artery bypass grafting (χ^2 tests, all $p<0.001$). The elderly had a higher risk of major adverse cardiovascular events within 30 days of PCI

(4.5% versus 2.7%, χ^2 test $p<0.001$). Over the seven years, there was a significant increase in the proportion of elderly patients who had multiple comorbidity (χ^2 test for trend, $p<0.001$). In spite of this, the underlying risk of complications did not change significantly over time either among the elderly (χ^2 test for trend, $p=0.142$) or overall (χ^2 test for trend, $p=0.083$).

Conclusions

Elderly patients have a higher risk of peri-procedural complications and account for an increasing proportion of PCIs. Despite this, the risk of complications following PCI has not increased over time.

Introduction

The prevalence of coronary heart disease increases with age. In line with other developed countries, the elderly account for an increasing proportion of the Scottish population, due to a combination of reduced fertility rates and increased life expectancy. Therefore, elderly patients represent an increasing proportion of those presenting for cardiovascular investigation and treatment. Previous studies have suggested that elderly patients are at greater risk of complications following percutaneous coronary intervention (PCI).[1-4] The past decade has seen the adoption into clinical practice of many developments shown to be effective at improving outcomes and reducing complications such as coronary stents, trans-radial access and adjuvant drug therapies.[2,5-9] Clinical trials have tended to exclude elderly patients.[5] Those studies that have included elderly patients suggest that the absolute benefit of these developments may be even higher in the elderly due to their high baseline risk.[5,9] The aim of this study was to examine whether the risk of peri-procedural complications following PCI is higher among elderly (≥75 years) patients than younger patients and whether it has changed over time.

Methods

Data sources and inclusion criteria

The Scottish Coronary Revascularisation Register collects comprehensive, prospective information on all patients undergoing PCI in Scotland, including demographic characteristics, postcode of residence, cardiac disease severity, co-morbidity, procedure details, past medical and surgical history, and in-hospital complications (http://www.scs-online.org.uk/cardreg.php). The Scottish Morbidity Record (SMR1) collects information on all admissions to acute hospitals in Scotland, including disease and procedure codes (http://www.datadictionaryadmin.scot.nhs.uk/isddd/9065.html). The General Registrar for Scotland (GROS) collates death certificate data across Scotland, including cause of death. Diseases are recorded using the International Classification of Diseases (ICD) and procedures using the Operating Procedure Codes (OPCS). The revascularisation register is linked annually to the SMR1 and death certificate data at an individual level, providing information on fatal and non-fatal events that occur following discharge. Our cohort comprised all patients who underwent non-emergency PCI in Scotland between April 2000 and March 2007 inclusive. The last linkage undertaken prior to our study provided follow-up events up to 27 June 2007.

Definitions

Elderly was defined as ≥75 years of age. Obesity was defined as a body mass index (BMI) greater than 30. Diabetes included both type I and type II diabetics. Hypertension was defined as systolic blood pressure ≥140mmHg, diastolic blood pressure ≥90mmHg or anti-hypertensive therapy. Non-cardiac arteriopathy included peripheral arterial disease, previous stroke, recurrent transient ischaemic attacks and carotid stenosis ≥70%. Impaired renal function was defined as serum creatinine >200mmol/l or use of renal replacement therapy. Impaired left ventricular function was defined as am ejection fraction of <50%. Multiple co-morbidity was defined as the presence of two or more of these conditions. Socioeconomic status was measured using the Scottish Index of Multiple Deprivation (SIMD) (http://www.scotland.gov.uk/Topics/Statistics/SIMD/). The SIMD is derived from 37 indicators across 7 domains (income, employment, health, education, skills and training, housing, geographic access and crime) and is used to rank data zones of residence (mean population of 750). The rankings have been used to produce deprivation quintiles for the general population which could then be applied to our study cohort using their postcode of residence. Peri-procedural outcomes were defined as events that occured either in-hospital or post discharge up to 30 days following PCI. The binary outcomes studied were all-cause death, fatal/non-fatal myocardial infarction and cardiac surgery, as well as the composite outcome of major adverse cardiovascular event (MACE) which was defined as being any of the above individual outcomes. Routine troponin measurement has not been adopted across Scotland. Peri-procedural MI was defined as EKG evidence of a Q wave MI over the whole study period. We also studied target vessel revascularisation (TVR) as a secondary outcome. This was defined as a repeat coronary revascularisation procedure, whether PCI or coronary artery bypass graft, undertaken on the same vessel as the original procedure.

Statistical analyses

The seven years of data were combined to compare binary case-mix variables in elderly and younger patients using χ^2 tests. The overall risk of adverse outcomes was compared using univariable and multivariable binary logistic regression models. In the latter, we adjusted for the potential confounding effects of sex, deprivation quintile, BMI, comorbidities, smoking status and disease severity. Changes in case-mix and crude outcomes over time were analysed using χ^2 tests for trend (linear-by-linear association) or Cuzick's test for trend[10] for variables that did not satisfy the assumptions of the χ^2 test for trend (linear by linear). Multivariable binary logistic regression analysis was performed including an interaction term for age-group and year of procedure, in order to determine whether the association between age-group and outcome changed over time after adjusting for the potential confounding factors listed above. The goodness of fit of the models was assessed using Hosmer and Lemeshow's test applied to 8, 10 and 12 groups of observed and predicted MACE. The analyses were undertaken using SPSS 15.0 and STATA 10.

Results

Overall comparison

Of the 35,888 patients who underwent PCI in Scotland between 2000 and 2007, 31,758 (88.9%) were classed as non-emergencies. Of these, 3,513 (11.1%) were performed in elderly patients and 28,245 (88.9%) in younger patients. Compared with younger patients, the elderly were more likely to be female, have multi-vessel disease, have multiple comorbidity, and have a past medical history of acute myocardial infarction or coronary artery bypass grafting (Table 1). Of the 31,758 patients, 567 (1.8%) were excluded from the outcome analysis because of missing or incomplete follow-up data. The missing patients were comparable to those included in the analysis in terms of the percentage of elderly (11.4% versus 12.4%, p=0.770) and male (72.1% versus 69.9%, p=0.251) patients. In the remaining cohort of 31,191 (98.2%) patients, the overall crude risk of MACE within 30 days of PCI was 4.5% in the elderly compared with 2.7% in younger patients (Pearson's χ^2 test, $p<0.001$) (Table 2). Elderly patients had an increased risk of both death and myocardial infarction but there was no significant difference in the risk of surgery or TVR (Table 2). In the overall logistic regression model, the increased risk of MACE among the elderly (unadjusted OR 1.74, 95% CI 1.46–2.08, $p<0.001$) was attenuated after adjustment for differences in case-mix (gender, smoking status, multi-vessel disease, obesity, hypertension, extra-cardiac arteriopathy, renal impairment, left ventricular dysfunction, and deprivation), but remained statistically significant (adjusted OR 1.52, 95% CI 1.17–1.98, $p<0.001$).

Time-trends

The overall number of non-emergency PCI procedures performed each year more than doubled, from 2,254 in 2000 to 5,522 in 2006 (Figure 1). Thereafter, the number fell slightly to 5,427 in 2007, mainly due to a reduction in procedures among younger patients. The absolute number of PCIs performed on the elderly increased from 196 in 2000 to 752 in 2007. The incidence of PCI among the elderly general population increased from 56/100,000 per annum in 2000 to 216/100,000 per annum in 2007. Among the general population aged 35-74 years, the incidence of PCI increased from 80/100,000 per annum to 192/100,000 per annum.

The elderly accounted for an increasing proportion of non-emergency PCIs, from 8.7% in 2000 to 13.9% in 2007 (χ^2 test for trend (linear-by-linear association), $p < 0.0001$). Among elderly patients, there was a significant increase in the prevalence of comorbidity due to diabetes and renal impairment (Table 3). There was a four-fold increase in multiple comorbidity in elderly patients, compared with only a two-fold increase in younger patients. The elderly were also characterised by increasing severity of cardiac disease with the prevalence of left ventricular dysfunction increasing from 37.7% to 55.4% (χ^2 test for trend (linear-by-linear association), $p<0.001$). The prevalence of multi-vessel disease remained the same in the elderly, compared with a 16.5% fall in younger patients.

The crude risk of MACE did not change significantly over time among either elderly or younger patients (χ^2 test for trend (linear-by-linear association), both $p<0.0001$) (Table 4) or overall (χ^2 test for trend (linear-by-linear association), both $p<0.0001$). In the multivariable binary logistic regression analysis, there was no significant interaction between year of procedure and age-group ($p=0.967$), suggesting that the association between age and outcome did not change significantly over time. The Hosmer and Lemeshow tests confirmed that the model was a good fit (8 groups p=0.598, 10 groups p=0.605, 12 groups p=0.667).

Discussion

Our results suggest that elderly patients have a higher risk profile and more adverse events, and that they account for an increasing number and proportion of non-emergency PCIs. Our findings add to the existing evidence from previous studies, focused on in-hospital events, that have reported a 4-5 fold increased risk of death,[2,4] and a 4-6 fold increased risk of MACE,[1-3] among elderly patients. The dramatic increase in numbers of PCI over time suggests a change in patient selection. Among elderly patients, the worsening case-mix suggests that PCI may now be used for patients who previously underwent surgery or were considered unfit for intervention. Among younger patients, the proportion with multi-vessel disease fell, suggesting that the increasing number may reflect use of PCI in less severe cases that may previously have been treated by medical therapy only. In spite of these trends, we demonstrated that, over time, the risk of adverse events has not increased either in the elderly or overall. Over the period studied many technical developments, new devices and adjuvant therapies, have been shown to be effective at improving PCI outcomes,[2,5-9] and have adopted into routine clinical practice in Scotland, as elsewhere. For example, over the period studied, deployment of coronary stents increased from 64% to 90% among elderly patients (64% to 94% among younger patients) and the use of ticlopidine or clopidogrel increased from 8.2% to 63% among elderly patients (10% to 66% among younger patients). In 2000, radial access was used in <5% of patients. In 2000, it was used in 40% patients (both elderly and younger). Our findings suggest that these advances have been sufficient to offset the effect of worsening risk profiles among patients.

Our cohort comprised all patients undergoing PCI in Scottish NHS hospitals, not a selected sample and therefore avoids selection bias. The registry data are detailed and comprehensive, and are collected prospectively by clinical staff at the patient's hospital. Most studies have only been able to report in-hospital complications.[1-4, 9] This has the potential to introduce bias since length of stay in hospital is longer in elderly patients[2] and has fallen over time due to an increase in day-case procedures.[11] Through linkage to routine data we were able to obtain outcomes up to 30-days of follow-up in both the elderly and younger patients. In Scotland, the follow-up information derived from SMR1 has been shown to be as complete and accurate as that obtained using conventional follow-up methods.[12] Unlike previous studies,[1-6,9] we excluded patients presenting with myocardial infarction since the use of primary and rescue PCI has significantly increased over time[13] and varies by age[14].

In any cohort study, there is always the potential for loss to follow-up due, for example due to migration from Scotland. However, this is less likely to occur with 30 day outcomes than long-term outcomes. The vast majority of patients were successfully linked to the follow-up databases. Only two percent could not be linked but there is no reason to suspect a systematic bias in the success of linkage, and analysis confirmed no significant statistical differences according to whether or not linkage was achieved.

Conclusions

The increasing percentage of elderly in the general population is expected to continue until at least 2031,[15] suggesting that the need for PCI in the elderly will continue to increase. This demographic trend, together with changes in patient selection and case-mix, will increase the underlying risk of peri-procedural complications. Our retrospective study suggests that, so far, we have managed to offset this effect, presumably as a result of technical improvements and the adoption of new devices and adjuvant therapies. However, further developments may be required if we are to avoid worsening outcomes in the future.

Conflicts of interest None declared

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Table 1. Comparison of characteristics of patients undergoing non-emergency percutaneous coronary intervention by age-group.

	≥75 years n (%)	<75 years n (%)	P value*
Male	2,062 (58.7)	20,151 (71.3)	<0.0001
Current smoker	1,122 (35.7)	8,284 (32.2)	<0.0001
Multi-vessel disease	1,899 (55.5)	11,041 (40.2)	<0.0001
Obese	457 (19.1)	6,005 (31.4)	<0.0001
Diabetes mellitus	631 (18.6)	4,879 (17.8)	0.228
Hypertension	1,780 (55.8)	11,877 (45.9)	<0.001
Extra-cardiac arteriopathy	478 (16.0)	2,263 (9.4)	<0.001
Renal impairment	91 (3.0)	330 (1.3)	<0.001
Left ventricular dysfunction	1,644 (52.6)	10,845 (42.5)	<0.001
Multiple comorbidity	629 (17.9)	3,875 (13.7)	<0.001
Previous PCI	481 (15.0)	4,130 (15.7)	0.277
Previous CABG	547 (16.6)	2,861 (10.7)	<0.001
Previous AMI	1,353 (38.5)	9,623 (34.1)	<0.001
Family history	807 (26.0)	10,974 (42.9)	<0.001

*Pearson's χ^2 test
n number, PCI percutaneous coronary intervention, CABG coronary artery bypass grafting, AMI acute myocardial infarction

Table 2. Comparison of crude 30 day outcomes following non-emergency percutaneous coronary intervention by age-group

	≥75 years n (%)	<75 years n (%)	P value*
All-cause death	57 (1.7)	154 (0.6)	<0.001
AMI	114 (3.3)	546 (2.0)	<0.001
Cardiac surgery	155 (0.6)	19 (0.6)	0.954
MACE	156 (4.5)	734 (2.7)	<0.001
TVR	47 (1.1)	309 (1.1)	0.193

*Pearson's χ^2 test

Table 3. Time trends in case-mix of patients undergoing non-emergency percutaneous coronary intervention by age-group.

	2000 n (%)	2001 n (%)	2002 n (%)	2003 n (%)	2004 n (%)	2005 n (%)	2006 n (%)	2007 n (%)	P value*
≥75 years									
male	124 (63.3)	130 (59.6)	141 (52.2)	212 (54.5)	257 (60.2)	340 (61.1)	418 (61.1)	440 (58.5)	0.485
current smoker	65 (44.5)	84 (42.9)	85 (35.6)	127 (38.8)	130 (31.9)	208 (38.0)	310 (33.9)	213 (32.0)	0.001
multi-vessel disease	85 (59.0)	115 (55.6)	140 (52.4)	212 (55.5)	244 (55.6)	312 (56.0)	384 (56.6)	407 (54.5)	0.098
obesity	39 (30.2)	30 (18.1)	31 (16.2)	53 (21.5)	51 (19.0)	68 (17.3)	87 (17.7)	98 (19.5)	0.126
diabetes mellitus	61 (31.4)	31 (14.8)	44 (16.5)	64 (17.3)	86 (20.0)	77 (13.8)	121 (18.4)	147 (21.0)	<0.001
hypertension	46 (31.3)	78 (39.4)	103 (43.6)	177 (51.5)	212 (51.5)	327 (59.6)	403 (64.2)	434 (63.9)	0.173
extra-cardiac arteriopathy	11 (5.6)	33 (15.1)	33 (12.2)	60 (15.7)	48 (10.8)	66 (11.7)	103 (15.1)	124 (16.5)	0.062
renal impairment	0 (0.0)	7 (4.3)	9 (7.7)	9 (9.9)	8 (8.8)	13 (14.3)	21 (23.1)	20 (22.0)	<0.001
left ventricular dysfunction	55 (37.7)	106 (51.2)	124 (46.8)	203 (53.4)	240 (55.3)	279 (54.1)	291 (52.9)	346 (55.4)	0.001
multiple comorbidity	12 (6.1)	29 (13.3)	35 (13.0)	61 (16.0)	70 (15.7)	107 (19.0)	150 (21.9)	165 (21.9)	<0.001
previous PCI	24 (15.8)	34 (16.4)	47 (17.9)	57 (16.6)	53 (12.8)	82 (14.9)	91 (14.6)	93 (14.0)	0.134
previous CABG	27 (19.6)	29 (14.0)	46 (17.4)	72 (19.5)	67 (15.5)	93 (16.6)	90 (14.0)	123 (18.2)	0.709
previous AMI	58 (29.6)	101 (46.3)	132 (48.9)	159 (41.5)	166 (37.3)	221 (39.1)	256 (37.4)	260 (34.6)	0.009
family history	73 (50.7)	60 (30.8)	54 (23.6)	81 (25.2)	88 (22.3)	141 (26.1)	151 (24.5)	159 (23.9)	<0.001
<75 years									
male	1,290 (67.2)	1,854 (68.3)	2,132 (70.7)	2,385 (72.4)	2,609 (72.3)	2,958 (71.5)	3,431 (70.9)	3,375 (72.2)	0.023
current smoker	705 (45.2)	829 (37.0)	835 (31.2)	923 (30.5)	985 (28.9)	1,305 (32.4)	1,435 (31.4)	1,267 (29.8)	<0.001
multi-vessel disease	847 (53.2)	1,026 (40.5)	1,061 (35.7)	1,223 (37.5)	1,473 (41.5)	1,656 (40.4)	1,920 (39.8)	1,835 (39.4)	<0.001
obesity	362 (25.5)	567 (30.1)	637 (30.8)	647 (30.1)	576 (28.9)	946 (32.9)	1,185 (33.7)	1,085 (33.7)	<0.001
diabetes mellitus	612 (30.2)	429 (16.9)	472 (16.9)	519 (16.3)	569 (16.0)	626 (15.4)	879 (18.6)	773 (17.6)	<0.001
hypertension	595 (37.7)	916 (40.4)	1,015 (37.8)	1,300 (42.4)	1,450 (42.3)	2,005 (49.7)	2,403 (52.5)	2,193 (51.6)	<0.001
extra-cardiac arteriopathy	97 (4.7)	222 (8.5)	246 (8.2)	276 (8.4)	250 (6.9)	336 (8.1)	434 (9.0)	402 (8.6)	0.013
renal impairment	3 (1.2)	6 (2.4)	2 (0.7)	3 (0.9)	12 (3.3)	6 (1.4)	22 (3.7)	13 (1.9)	0.025
left ventricular dysfunction	559 (35.1)	1,029 (41.1)	1,180 (40.1)	1,412 (43.5)	1,412 (40.2)	1,603 (41.8)	1,691 (42.1)	1,959 (48.9)	<0.001
multiple comorbidity	162 (7.9)	313 (12.0)	360 (11.9)	415 (12.6)	453 (12.6)	616 (15.3)	788 (16.3)	730 (15.6)	<0.001
previous PCI	331 (20.2)	439 (18.1)	569 (19.3)	440 (14.4)	453 (13.1)	541 (13.4)	696 (15.2)	661 (15.7)	<0.001
previous CABG	211 (13.3)	334 (13.7)	339 (11.4)	371 (11.7)	358 (10.1)	425 (10.4)	427 (9.2)	396 (9.4)	<0.001
previous AMI	597 (29.0)	992 (37.9)	1,148 (38.1)	1,251 (38.0)	1,214 (33.6)	1,390 (33.6)	1,635 (33.8)	1,396 (29.5)	<0.001
family history	769 (49.4)	1,076 (48.3)	1,122 (42.2)	1,229 (41.1)	1,319 (39.0)	1,801 (44.8)	1,987 (43.6)	1,671 (39.6)	<0.001

*χ2 test for trend (linear-by-linear association)
n number, PCI percutaneous coronary intervention, CABG coronary artery bypass grafting, AMI acute myocardial infarction

Table 4. Time trends in crude 30 day outcomes following non-emergency percutaneous coronary intervention by age-group.

	2000 n (%)	2001 n (%)	2002 n (%)	2003 n (%)	2004 n (%)	2005 n (%)	2006 n (%)	2007 n (%)	P value*
≥75 years									
	n=192	n=202	n=267	n=377	n=442	n=560	n=679	n=730	
All-cause death	2 (1.0)	2 (1.0)	4 (1.5)	6 (1.6)	10 (2.3)	7 (1.3)	10 (1.5)	16 (2.1)	0.780
AMI	1 (0.5)	7 (3.5)	6 (2.3)	15 (4.0)	13 (2.9)	20 (3.7)	25 (3.7)	27 (3.7)	0.792
Cardiac surgery	2 (1.0)	0 (0.0)	2 (0.8)	1 (0.3)	2 (0.9)	4 (0.7)	3 (0.4)	3 (0.4)	0.667
MACE	**5 (2.6)**	**7 (3.5)**	**10 (3.7)**	**18 (4.8)**	**20 (4.5)**	**29 (5.2)**	**31 (4.6)**	**36 (4.9)**	**0.142**
TVR	3 (1.6)	3 (1.5)	6(2.2)	7(1.9)	4(0.9)	13(2.3)	17 (2.5)	11 (1.5)	0.711
<75 years									
	n=1,982	n=2,475	n=2,976	n=3,269	n=3,550	n=4,095	n=4,813	n=4,582	
All-cause death	10 (0.5)	10 (0.4)	12 (0.4)	18 (0.6)	26 (0.7)	27 (0.7)	26 (0.5)	25 (0.6)	0.349
AMI	25 (1.7)	34 (1.4)	54 (1.8)	65 (2.0)	83 (2.3)	98 (2.3)	104 (2.2)	83 (1.8)	0.024
Cardiac surgery	11 (1.1)	21 (0.8)	16 (0.5)	22 (0.6)	23 (0.6)	25 (0.6)	15 (0.3)	22 (0.5)	0.041
MACE	**42 (2.2)**	**58 (2.4)**	**72 (2.5)**	**90 (2.8)**	**111 (3.2)**	**127 (3.2)**	**127 (2.7)**	**107 (2.4)**	**0.405**
TVR	23 (1.2)	39 (1.6)	53 (1.8)	62 (1.9)	61 (1.7)	79 (1.9)	74(1.5)	73(1.6)	0.660

* Cuzick's test for trend[10] for cardiac surgery in elderly; χ^2 test for trend (linear-by-linear association) in the remainder
n number, AMI acute myocardial infarction, MACE major adverse cardiovascular event, TVR target vessel revascularisation

Figure 1. Numbers of non-emergency percutaneous coronary interventions per annum by age-group.