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Percutaneous coronary intervention in octogenarians: 10-year experience from a primary percutaneous coronary intervention centre with off-site cardiothoracic support

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ABSTRACT

OBJECTIVE To examine the trends in patient characteristics and clinical outcomes over a ten-year period and to analyse the predictors of mortality in octogenarians undergoing percutaneous coronary intervention (PCI) in our centre.

METHODS A total of 782 consecutive octogenarians (aged 80 and above) were identified from a prospectively collected PCI database within our non-surgical, medium volume centre between 1st January 2007 and 31st December 2016. This represented 10.9% of all PCI procedures performed in our centre during this period. We evaluated the demographic and procedural characteristics of the cohort with respect to clinical outcomes (all-cause in-hospital and 1-year mortality, in-hospital complication rates, duration of hospital admission, coronary disease angiographic complexity and major co-morbidities). The cohort was further stratified into three chronological tertiles (January 2007 to July 2012, 261 cases; August 2012 to May 2015, 261 cases; June 2015 to December 2016, 260 cases) to assess for differences over time. Predictors of mortality were identified through a multivariate regression analysis.

RESULTS The number of octogenarians undergoing PCI increased nearly ten-fold over the studied period. Despite this, there were no significant differences in clinical outcomes or patient characteristics, except for the increased use of trans-radial vascular access [11.9% in first tertile *vs.* 73.2% in third tertile ($P < 0.0001$)]. The all-cause in-hospital (5.8% *vs.* 4.6% *vs.* 3.8%, $P = 0.578$) and 1-year mortality (12.4% *vs.* 12.5% *vs.* 14.4%, $P = 0.746$) remained constant in all three tertiles respectively. Six independent predictors of mortality were identified - increasing age [HR = 1.12 (1.03−1.22), $P = 0.008$], cardiogenic shock [HR = 16.40 (4.04–66.65), $P < 0.0001$], severe left ventricular impairment [HR = 3.52 (1.69−7.33), $P = 0.001$], peripheral vascular disease [HR = 2.73 (1.22−6.13), $P = 0.015$], diabetes [HR = 2.59 (1.30−5.17), $P = 0.007$] and low creatinine clearance [HR = 0.98 (0.96−1.00), $P = 0.031$].

CONCLUSION This contemporary observational study provides a useful insight into the real-world practice of PCI in octogenarians.

Although age is a major cardiovascular risk factor which has a marked impact on the prevalence of coronary artery disease (CAD) and cardiovascular mortality,[1] there is a recognised reluctance in offering percutaneous coronary intervention (PCI) to octogenarians (≥ 80 years old),[2] despite its proven benefit in this age group.[3–5] As a result, an increasing number of octogenarians undergoing PCI is observed, reaching almost 10% of all PCI procedures performed in United Kingdom in the period 2008–2012.[6]

Despite the increasing demand for PCI in the octogenarians, this patient population remains under-represented in randomised trials or only a highly selected group is investigated.[7,8] Emerging evidence shows that the survival advantage of invasive compared with non-invasive management appears to extend to patients with non-ST elevation myocardial infarction (NSTEMI) who are octogenarians,[4,9] although predictably, mortality rates are higher in patients undergoing primary PCI for STEMI.[10]

In the absence of robust randomised clinical data on PCI treatment strategies for the octogenarians, observational studies remain valuable in providing insights to outcome and mortality trends. As a result, we aimed to evaluate the characteristics of our "real world" octogenarian patient population presenting over a ten-year period to a PCI centre with off-site cardiothoracic support in terms of demographics, the procedural and clinical outcomes, and any potential predictors of mortality.

METHODS

A total of 782 consecutive octogenarian patients were identified from a prospectively collected PCI database within our non-surgical, medium volume centre over a ten-year period between 1st January 2007 and 31st December 2016. This represented 10.9% of all PCI procedures performed in our centre during this period. Patient and procedural characteristics and data relating to outcomes was recovered from electronic patient record. The analysis was aimed to evaluate the characteristics of the cohort with respect to the all-cause in-hospital and 1-year mortality, in hospital major adverse cardiovascular events (MACE) rates, duration of hospital admission, angiographic complexity of CAD as described by the Synergy Between Percutaneous Coronary Intervention With Taxus and Coronary Artery Bypass Surgery (SYNTAX) score (assessed independently by two experienced interventional cardiologists) and major comorbidities. A multivariate analysis was performed to examine potential predictors of mortality in this patient cohort. In order to quantify the medical complexity and comorbidity of patients, each patient was assigned a composite comorbidity score (CCS) 0-6 if they were showing one or more characteristics that were found to be associated with increased mortality (e.g., CCS 1 for one factor, CCS 3 for three factors etc). Finally, the patient population was stratified into three chronological tertiles to evaluate any temporal trends.

Statistical Analysis

Statistical analysis was performed using SPSS statistical software, version 25.0 (IBM, Armonk, NY, USA). Categorial variables are presented as count and frequency in percentage. The continuous variables were tested for normal distribution using the Kolmogorov-Smyrnov test. Normally distributed continuous variables were reported as mean ± SD, with non-normally distributed data reported as mean [range]. Variables were presented with hazard ratios (HR) and 95% confidence intervals (CI). The patients were stratified into three chronological tertiles with equal numbers of patients.

Between-group differences in continuous variables were evaluated with the Mann-Whitney *U* test. Comparisons between the categorical variables were performed using Pearson's chi-square test or one-way ANOVA, as appropriate, with a significance level of $P < 0.05$.

Following uni-variate analyses, we identified potential predictors of mortality (variables with a *P*-value < 0.05), which were subsequently jointly included in a multi-variate analysis to identify independent predictors of mortality, presented as HR and 95% CI. In the multivariate model, we have opted to use 10 events per variable as it is a widely advocated minimal criterion for sample size considerations in logistic regression analysis. A *P*-value < 0.05 was considered significant. Cumulative event rates of all-cause mortality were analysed using the Kaplan-Meier method.

RESULTS

Over the studied ten-year period, the number of PCI procedures performed in our centre doubled overall, while the number of PCI procedures in octogenarians increased nearly tenfold, from 19 performed in 2007 (4% of all PCI) to 178 in 2016 (16.9% of all PCI) (Figure 1).

Baseline Characteristics

The 782 consecutive octogenarians were further characterised according to the mode of presentation, co-morbid status, angiographic complexity of CAD, in-hospital complications, and 1-year mortality (Table 1).

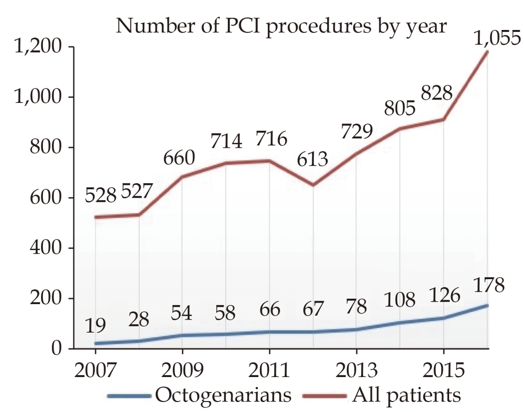

Figure 1 Annual number of PCI procedures performed at our centre between 2007 and 2016. PCI: percutaneous coronary intervention.

Table 1 Patient characteristics.

Characteristic	Result
Number of patients	782
Age, yrs	84 (80–96)
80-84	513 (65.6%)
85–89	217 (27.7%)
90	52 (6.6%)
Sex (male)	473 (60.4%)
Mode of presentation	
Stable angina	142 (18.2%)
ACS	634 (81.1%)
NSTEMI/UA	502 (79.1%)
STEMI	132 (20.8%)
Staged PCI	6 (0.7%)
Cardiogenic shock	25 (3.2%)
SYNTAX score	16 (1–54)
Residual SYNTAX score	7 (0-45)
Previous MI	268 (34.3%)
Previous PCI	176 (22.5%)
Previous CABG	103 (13.2%)
Diabetes	160 (20.5%)
Diet-controlled	26 (16.3%)
NIDDM	90 (56.3%)
IDDM	44 (27.5%)
BMI, kg/m^2	26.0 (13.5–42.8)
> 18.5	19 (2.4%)
18.6–25	305 (39.0%)
25.1–30	272 (34.8%)
30.1	186 (23.8%)
LV function	
Good/Mildly impaired	421 (53.8%)
Moderately impaired	202 (25.8%)
Severely impaired	80 (10.2%)
Unknown	79 (10.1%)
Smoker (current or ex)	241 (30.9%)
Hypercholesterolaemia	375 (48.0%)
Hypertension	583 (74.6%)
Previous CVA	64 (8.2%)
Peripheral vascular disease	92 (11.8%)
Arterial access route	
Radial	382 (48.8%)
Femoral	383 (49.0%)
Brachial	2 (0.2%)
Dual	14 (1.8%)
Glycoprotein IIb/IIIa use	103 (13.2%)
Tirofiban	67 (65.0%)
Abciximab	36 (35.0%)
Eptifibatide	0
Adjunctive tools	37 (4.7%)
Pressure wire	13 (35.1%)
IVUS	7 (18.9%)
Rotational atherectomy	17 (45.9%)
Stents used	
DES	519 (66.3%)
BMS	187 (23.9%)
Both	21 (2.7%)
None (e.g., POBA only)	55 (7.0%)
Length of stay, days	4 (0–101)
Stable angina	1 (0–7)
Acute coronary syndrome	4 (0–101)
NSTEMI/UA	3 (0–61)
STEMI	8 (0–101)
Staged PCI	1 (0–3)
In hospital complications	90 (11.5%)
Arterial complications	7
CVA	4
GI bleeding	6
Blood transfusion	9
Re-intervention	6
In hospital death	37
QMI	1
NQMI	1
Reintervention	5
Re-infarction	1
Other*	30
1-year mortality n (%)	102 (13.0%)

Data are presented as *n* (%) or mean (range). ACS: acute coronary syndrome; BMI: body mass index; BMS: bare metal stent; CABG: coronary artery bypass graft; CVA: cerebrovascular accident; DES: drug-eluting stent; GI: gastrointestinal; IDDM: insulin-dependent diabetes mellitus; IVUS: intravascular ultrasound; LV: left ventricular; MI: myocardial infarction; NB: some patients could suffer more than one complication; NIDDM: non-insulin-dependent diabetes mellitus; NSTEMI: non ST elevation myocardial infarction; PCI: percutaneous coronary intervention; POBA: balloon angioplasty; STEMI: ST elevation myocardial infarction; SYNTAX: Synergy between PCI with Taxus and Cardiac Surgery score; UA: unstable angina. *Other includes unlisted complications.

Of these 473 (60.4%) were male and 634 (81.2%) patients presented with an acute coronary syndrome (ACS), including 132 patients who presented with STEMI and 502 patients with NSTEMI. Among these 268 (34.3%) had suffered a previous MI, 176 (22.5%) had undergone a previous PCI and 103 (13.2%) had undergone prior coronary artery bypass grafting (CABG). A previous history of diabetes mellitus was found in 160 (20.5%), hypercholesterolaemia in 375 (48%), hypertension in 583 (74.6%), previous history of a cerebrovascular event in 64 (8.2%) and 92 (11.8%) had peripheral vascular disease. There was a near-even split of the use of radial *vs.* femoral access route (48.8% *vs.* 49%). The average angiographic SYNTAX score was 16, with a range of 1–54. Majority of patients (66.3%) received drug-eluting stents. Glycoprotein IIb/IIIa was used in 13.2% of cases, with Tirofiban being the preferred agent (65%).

In Hospital and 1-year Adverse Outcomes

The average length of stay for patients with stable angina was 1 day, and 4 days for patients with ACS. A total of 90 (11.5%) patients suffered in-hospital complications, including 37 (4.73%) who died in hospital. The 1-year mortality was 102 (13.04%). Mortality rates were higher, as expected, in patients undergoing primary PCI for STEMI (Table 2).

Temporal Changes in Patient Characteristics and Outcomes

The patients were then subdivided into three chronological tertiles with equal numbers of patients (January 2007 to July 2012, 261 cases; August 2012 to May 2015, 261 cases; June 2015 to December 2016, 260 cases). These cohorts were then compared to assess for differences between groups. Overall, the cohorts were found to be largely similar, except for the greater use of radial access (P < 0.0001), previous history of PCI (P = 0.026), and a greater proportion of patients with multivessel CAD (P = 0.011) (Table 3). A Kaplan-Meier analysis found no significant difference in the 1-year mortality between the three chronological cohorts (Figure 2).

Independent Predictors of Mortality

A univariate analysis identified several factors associated with increased mortality (Table 4). These were further included in a multivariate model, which identified six independent predictors of increased mortality: increasing age (HR = 1.12 (1.03–1.22), P = 0.008), presence of cardiogenic shock (HR = 16.40 (4.04–66.65), P < 0.0001), presence of diabetes mellitus (HR = 2.59 (1.30–5.17), P = 0.007), presence of severe left ventricular impairment (HR = 3.52 (1.69–7.33), P = 0.001) and presence of peripheral vascular disease (HR = 2.73 (1.22–6.13), P = 0.015). Creatinine clearance was also found to be an independent inverse predictor of mortality (HR = 0.98 (0.96–1.00), P = 0.031).

Each patient was assigned a composite comorbidity score between 0–6 if they were found to be exhibiting one or more characteristics that were predictive of increased mortality. The patients were further subdivided into chronological tertiles and comorbidity scores (Table 5). Statistical analysis (one-way ANOVA) did not reveal any significant differences between the chronological cohorts in terms of the composite comorbidity score (P = 0.486).

DISCUSSION

We conducted the most contemporary observational study examining trends and outcomes of the

Table 2 In-hospital and 1-year mortality.

Clinical syndrome/*n*	In-hospital mortality	1-year mortality
SA and Staged PCI/148	1 (0.67%)	7 (4.73%)
NSTEMI/502	16 (3.19%)	66 (13.15%)
STEMI/132	20 (15.15%)	29 (21.96%)
−/782	37 (4.73%)	102 (13.04%)

NSTEMI: non ST elevation myocardial infarction; SA: stable angina; STEMI: ST elevation myocardial infarction; PCI: percutaneous coronary intervention.

Table 3 Comparison of cohorts by chronological tertiles.

Characteristics	Chronological tertiles			*P*-value
	Jan 2007 to Jul 2012	Aug 2012 to May 2015	Jun 2015 to Dec 2016	
Number of patients	261	261	260	
Age at procedure	83 (80–94)	84 (80–96)	84 (80–95)	0.101
Length of stay (in days)	4.08 (0–101)	3.70 (0–61)	3.21 (0–44)	0.332
Male gender	150 (60.8%)	157 (60.2%)	158 (60.5%)	0.990
Acute coronary syndrome	215 (82.7%)	214 (82.0%)	208 (79.7%)	0.655
Cardiogenic Shock	7 (2.7%)	9 (3.4%)	9 (3.5%)	0.855
Previous MI	95 (36.5%)	85 (32.9%)	88 (33.7%)	0.664
Prior CABG	27 (10.4%)	38 (14.6%)	38 (14.6%)	0.267
Previous PCI	46 (17.7%)	58 (22.2%)	72 (27.6%)	0.026
Diabetes mellitus				
0 – none	206 (79.2%)	206 (78.9%)	210 (80.5%)	
1 – diet controlled	4 (1.5%)	11 (4.2%)	7 (2.7%)	0.900
2 – NIDDM	34 (13.1%)	30 (11.5%)	30 (11.5%)	
3 – IDDM	16 (6.2%)	14 (5.4%)	14 (5.4%)	
LV impairment				
0 – none/mild	123 (56.4%)	152 (62.6%)	146 (60.3%)	
1 – moderate	68 (31.2%)	61 (25.1%)	73 (30.2%)	0.526
2 – severe	27 (12.4%)	30 (12.3%)	23 (9.5%)	
Smoker	89 (36%)	66 (28.6%)	86 (34.0%)	0.204
Hypercholesterolemia	121 (48.4%)	120 (47.8%)	134 (52.1%)	0.571
Hypertension	195 (77.1%)	184 (71.0%)	204 (78.2%)	0.128
PVD	36 (14.0%)	25 (9.7%)	31 (11.9%)	0.318
CVD	27 (10.5%)	24 (9.2%)	13 (5.0%)	0.058
Creatinine clearance, mL/min	47.41 (16.36–104.27)	48.75 (10.47–163.34)	47.49 (6.56–94.64)	0.613
Arterial access				
1 – Femoral	226 (86.9%)	97 (37.2%)	61 (23.4%)	
2 – Brachial	1 (0.4%)	0	1 (0.4%)	< 0.0001
3 – Radial	31 (11.9%)	160 (61.3%)	191 (73.2%)	
4 – Dual	2 (0.8%)	4 (1.5%)	8 (3.1%)	
Multi-vessel CAD	224 (86.1%)	244 (93.5%)	240 (92.0%)	0.011
LMS-PCI	13 (5.0%)	21 (8.0%)	24 (9.2%)	0.169
Mean SYNTAX score	15.5 (1–48)	16.0 (2–52.5)	17.0 (1–54)	0.407
Mean Residual SYNTAX score	6.80 (0–38)	7.0 (0–45)	7.5 (0–42)	0.935
In-hospital complications	28 (10.9%)	25 (9.6%)	33 (12.6%)	0.533
In-hospital mortality	15 (5.8%)	12 (4.6%)	10 (3.8%)	0.578
1-year mortality	32 (12.4%)	32 (12.5%)	37 (14.4%)	0.746

Data are presented as n (%) or mean (range). CABG: coronary artery bypass graft; CVD: cerebrovascular disease; IDDM: insulin-dependent diabetes mellitus; LV: left ventricular; MI: myocardial infarction; NIDDM: non-insulin-dependent diabetes mellitus; PCI: percutaneous coronary intervention; PVD: peripheral vascular disease; SYNTAX: Synergy between PCI with Taxus and Cardiac Surgery score.

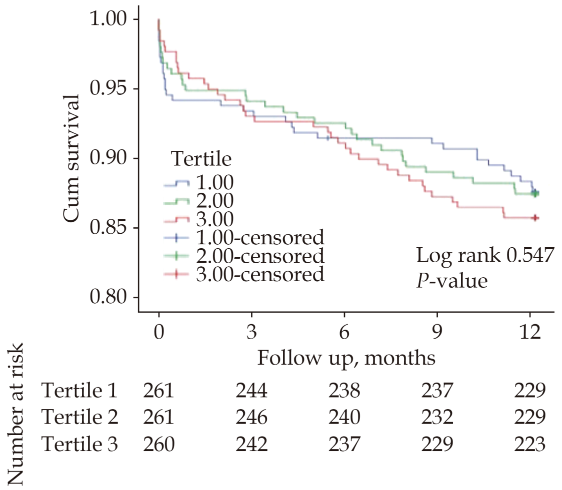

Figure 2 Kaplan Meier curve assessing survival within three chronological cohorts. Log rank (Mantel-Cox 0.547, *P*-value = 0.761).

use of PCI in octogenarians in a centre with off-site cardiothoracic support, which should contribute towards the current limited evidence base in this area.

First, we found that the use of PCI in octogenarians had increased nearly ten-fold during the 10-year study period. In 2016, PCI procedure performed in octogenarians in our centre exceeded 16.8% of all procedures performed. The British Cardiovascular Intervention Society (BCIS) audit for the same period found PCI use in octogenarians at 12.5%.[11] This difference may be partially explained by the differences in our catchment population (5.7% patients older than 80 years old *vs.* 4.9% in England),[12] but also by operator variability and experience in performing PCI in these high-risk patients.

Octogenarians are likely to have significant age-

Table 4 Univariate and multivariate analysis of factors predictive of mortality in octogenarians undergoing PCI.

Variable	Univariate analysis		Multivariate analysis	
	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
Age, yrs	1.14 (1.08–1.21)	< 0.0001	1.12 (1.03–1.22)	0.008
Sex (female)	0.78 (0.50-1.21)	0.261		
Length of stay	1.05 (1.02–1.07)	0.001		
Acute coronary syndrome	4.03(1.73–9.38)	0.001	1.16 (0.46–2.93)	0.756
Cardiogenic shock	33.25 (12.15–91.02)	< 0.0001	16.40 (4.04–66.65)	< 0.0001
Previous MI	1.12 (0.72–1.73)	0.627		
Previous CABG	0.68 (0.34–1.36)	0.278		
Previous PCI	0.57(0.32–1.02)	0.057		
Diabetes mellitus	1.88 (1.18–2.99)	0.008	2.59 (1.30-5.17)	0.007
Hypertension	0.65 (0.41–1.03)	0.06		
Hypercholesterolemia	1.17 (0.76–1.80)	0.47		
Smoker (ex or current)	1.28 (0.81–2.02)	0.29		
Creatinine clearance	0.96 (0.94–0.97)	< 0.0001	0.98 (0.96–1.00)	0.031
Severe LV impairment	2.33 (1.47–3.68)	< 0.0001	3.52 (1.69–7.33)	0.001
Peripheral vascular disease	3.55 (2.13–5.91)	< 0.0001	2.73 (1.22–6.13)	0.015
CVA	0.54 (0.21–1.39)	0.204		
Multi-vessel disease	1.82 (0.71–4.64)	0.212		
Vascular access (Radial)	1.51 (0.99–2.32)	0.058		
LMS-PCI	3.11 (1.69–5.72)	< 0.0001	1.01 (0.33–3.12)	0.986
SYNTAX score	1.06 (1.04–1.08)	< 0.0001	1.03 (0.98–1.08)	0.304
Residual SYNTAX score	1.07 (1.05–1.09)	< 0.0001	1.02 (0.97–1.07)	0.465

CABG: coronary artery bypass graft; CVA: cerebrovascular accident; LMS-PCI: left main stem percutaneous coronary intervention; LV: left ventricular; MI: myocardial infarction; PCI: percutaneous coronary intervention; SYNTAX score: Synergy Between Percutaneous Coronary Intervention With Taxus and Coronary Artery Bypass Surgery score.

Table 5 Chronological tertiles subdivided by composite comorbidity score.

		Chronological tertiles		
		Jan 2007 - Jul 2012	Aug 2012 – May 2015	Jun 2015 – Dec 2016
Composite comorbidity score	0	42	52	62
	1	100	94	89
	2	78	75	77
	3	33	32	24
	4	5	6	9
	5	2	2	0
	6	0	0	0

related comorbidities, and they are more likely to suffer from complications relating to increased bleeding risk or renal failure.[13–15] Indeed, in our study we found 34.1% of patients had suffered a previous MI, 13.2% had prior CABG, 20.5% were suffering with diabetes mellitus, 10.2% had severe LV impairment and 11.8% had peripheral vascular disease. Despite this burden of comorbidities, the incidence of complications remained low, with seven episodes of arterial complication, four episodes of stroke and nine episodes of bleeding requiring a blood transfusion. The all-cause in-hospital mortality was 4.7%, which is lower than what was reported in the GRACE registry.[16] In addition, previous observational studies have found that PCI performed in a centre with offsite cardiothoracic support is not associated with an increased mortality hazard.[17] Our data suggests that in appropriately selected octogenarian patients, PCI is a safe mode of revascularization, even in centres without on-site cardiothoracic support.

Our study showed that octogenarians were significantly more likely to undergo PCI for an ACS as compared to stable angina (81.1% ACS, 18.9% stable angina/staged PCI). In comparison, the BCIS data suggests that in the UK, 64.8% of PCI procedures are performed for acute indications, whilst 35.2% are performed for stable angina.[11] This staggering difference may suggest that PCI is underutilised as a treatment strategy for octogenarian patients with stable angina. This imbalance may also falsely exaggerate the procedural complication rates and mortality in this cohort, as patients presenting acutely are more likely to have uncontrolled comorbidities or cardiovascular instability.

Despite the significant increase in the number of octogenarians undergoing PCI, we found that the patient characteristics had not changed significantly over the 10-year study period. We however, found a statistically significant difference in the use of the radial artery access, which is consistent with trends worldwide.[18] Interestingly, there were no statistically significant differences in the uptake of patients who were characterised by predictors found to be associated with an increased risk of mortality, either individually or in combination, as assessed by the composite comorbidity score. This perhaps explains the lack of any significant differences in complication rates or all-cause mortality over the years and suggests that our elderly patient population undergoing PCI has been appropriately selected.

This study identified independent predictors of mortality in our elderly population. This included increasing age, presence of cardiogenic shock on admission, severe LV impairment, presence of diabetes mellitus, peripheral vascular disease and renal impairment. These factors have previously been identified by other studies,[6] and clinicians often factor these in, when balancing risk versus benefit in this age group. For the octogenarians, despite high rates of bleeding, bleeding does not appear to be predictive of mortality following PCI, which is concordant with the study of Li, *et al*[19]. A possible explanation for the lack of association between bleeding and mortality for this population is that octogenarians have increasing number of threats to their mortality that are independent from bleeding complications and that this weakens the relationship between bleeding and mortality.

LIMITATIONS

This is a retrospective observational study from a single centre, which is subject to bias. Although majority of data was collected prospectively at the time of the procedure, some datasets was missing and needed to be obtained from multiple patient systems by several operators. For the purpose of this paper, we have derived a composite comorbidity score which requires further validation in future studies. While our study enhances the available limited evidence base in this area, further randomised controlled trial data is required to help guide management options in this challenging patient population.

CONCLUSIONS

This observational study shows that PCI is a safe and effective method of revascularisation in octogenarians presenting with stable angina or acute coronary syndrome in centres with off-site cardiothoracic support.

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