



Safety, Feasibility and Economic Analysis of Same Day Discharge Following Elective Percutaneous Coronary Intervention

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ABSTRACT

BACKGROUND: Advances in percutaneous coronary intervention (PCI) has made the possibility of facilitating same day discharge (SDD) of patients undergoing intervention. We sought to investigate the feasibility, safety and economic impact of such a service.

METHODS: We retrospectively collected data on all patients undergoing outpatient PCI at our institution over a 12-month period. We included in-hospital and 30-day major adverse cardiac events (MACE), vascular complications, acute kidney injury and any re-hospitalisations. We analysed the cost effectiveness of SDD compared to overnight admission post PCI and staged PCI following diagnostic angiography.

RESULTS: A total of 147 patients undergoing PCI with 129 patients deemed suitable for SDD (88%). Mean age was 65.7 years. Most patients had type C lesions (60.3%); including 4 chronic total occlusions (CTOs). At 30-day follow-up there were no MACE events (0%). There were 10 (7.8%) re-hospitalisations of which majority (70%) were non cardiac presentations. We also included cost analysis for an elective PCI with SDD, which equated to \$2090 per patient (total of \$269610 for cohort). Elective PCI with an overnight admission was \$4440 per patient (total of \$572760 for cohort), an additional \$2350 per patient (total \$303150). Total cost of an angiogram followed by a staged PCI with an overnight stay was \$4700 per patient (total \$606300).

CONCLUSION: SDD is safe and feasible in the majority of patients that have elective coronary angiography that require PCI. SDD leads to a significant reduction in total cost and hospital stay of patients undergoing elective PCI.

KEYWORDS: Percutaneous coronary intervention, same day discharge, cost, safety, outcomes

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Introduction

Advances in percutaneous coronary intervention (PCI) have led to increased patient safety and recovery. Technologies contributing to these improvements include trans-radial access with smaller-sized guiding catheters (5-F, 6-F), improved antithrombotic agents and the use of femoral artery closure devices.¹ Early studies of same day discharge (SDD) were low powered and did not gain acceptance due to fear of early adverse events within 24 hours, in particular stent thrombosis, vascular complications and arrhythmia.²⁻⁴ Nevertheless, the increased safety and reduced complications of PCI has enabled elective patients to be discharged on the same day and this has been shown to be safe and feasible in multiple studies.⁵⁻⁹

Several meta-analyses have also shown that patients discharged on the same day had similar rates of major adverse cardiovascular events, repeat hospitalisations and overall complications as the patients who were observed overnight.¹⁰⁻¹² Patient heterogeneity, procedural characteristics and definitions of complications among the various studies are limitations of

the meta-analyses. These studies provide the best evidence to date with regards to the safety of same-day discharge in PCI. Despite the low risk, most patients continue to be admitted overnight for observation. Justifications for this include concerns over safety and medicolegal risk, the under-recognised cost benefit of same-day discharge and a lack of consensus on the appropriate eligibility criteria for SDD with trial criteria often excluding suitable patients.

Additional benefits of SDD include procedural cost minimisation, increased hospital efficiency and improve patient satisfaction. Several studies have highlighted potential financial savings with SDD, primarily by avoiding the cost of an overnight stay.¹³⁻¹⁶ The cost effectiveness of SDD has been shown in a large Canadian study,¹⁷ which showed that SDD was associated with 50% relative risk reduction in health care cost, and a mean saving per patient of \$1086.6 USD. Similarly, a Canadian study showed an estimated cost saving of \$1247 Canadian dollars (~\$790 USD) per patient.¹⁸ An American study also demonstrated cost saving with an average saving of



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\$5128 USD per PCI.¹⁶ European studies have also reported cost savings with a saving of €1210 (\$1523 USD) per patient.¹⁹ In Australia, with an average cost of \$2000 AUD per overnight stay provides a potential opportunity for substantial savings annually.²⁰ Finally, patient satisfaction score has been shown to be significantly higher with SDD rather than with overnight observation.²¹

Despite evidence supporting SDD in elective PCI cases, there is little data in Australia regarding outcomes and the practice is uncommon. A small study demonstrated the safety of an SDD strategy in both short and long-term outcomes using post PCI troponin levels.⁵ In an Australian context the rate of SDD is low with over 95% admitted overnight.²² Our study aims to assess the safety and feasibility of SDD for patients undergoing elective PCI. Secondly, we analyse the economic benefits of this approach which has not been previously investigated locally. Thirdly, this approach to patient care was developed and implemented at the same time as the commencement of a new PCI capable centre, making the findings applicable to all coronary interventional centres irrespective of practice age.

Material and Methods

Study population

We included patients who underwent elective percutaneous coronary intervention (PCI) at Bankstown-Lidcombe Hospital from February 2019 to February 2020. All data was collected from electronic medical health records. We retrospectively collected baseline demographics, clinical characteristics, procedure details and in-hospital outcomes. The inclusion criteria included outpatients with stable angina or angina equivalent symptoms referred for angiography. We excluded patients with unstable angina or acute coronary syndrome (ACS). Patients admitted post procedure were excluded from the study, although their data was still collected and analysed. We collected data on vascular access, use of haemodynamic assessment or intra-coronary imaging, lesion characteristics, target vessel, stent selection and closure devices, all of which were left to the discretion of the treating interventionist. Patients were deemed suitable for same day discharge included: age <80 years, presence of a relative or carer at home, English-speaking or English-speaking relative at home and absence of procedural complications.

Study endpoints

The primary outcome was major adverse cardiovascular events (MACE) at 30 days follow up defined as composite of cardiac death, myocardial infarction, stroke or target vessel revascularisation. Secondary outcomes included re-hospitalisation, bleeding, vascular complications, stroke and myocardial infarction at 30 days. Same day discharge was considered to have occurred if patients were discharged on same day of PCI procedure.

Cost analysis of same day discharge was according to the National Hospital Cost Data Collection (NHCDC).²⁰

The study was approved by the local ethics committee and performed according to the Declaration of Helsinki.

Statistical analysis

Continuous variables were presented as means \pm standard deviations. Categorical data were presented as frequencies and percentages. Cost analysis was performed using Analysis of Variance (ANOVA). All *P*-values < .05 were considered statistically significant. We used IBM-SPSS Version 26 (IBM Corporation, Armonk, New York) and Excel 2019 (Microsoft Corporation, Redmond, Washington) for all statistical analysis.

Economic analysis

We endeavoured to include costs associated with hospital admission and procedure related expenses. Estimated hospital admission costs were based on data from the National Hospital Cost Data Collection (NHCDC).²¹ The NHCDC provides an annual collection of public hospital cost data across all Australian territories. This data includes both acute admissions in addition to sub-acute presentations. In the public sector, cost for overnight admission was approximately \$2000 per night with the addition of required pathology, electrocardiograms and monitoring. The cost of PCI was the sum of sheath, diagnostic catheter, guiding wire and catheter, intracoronary wire, inflation device, pre- and post-dilatation balloons and the stent. Cost analysis in our study was the sum of hospital admission procedural costs.

Results

There were 792 coronary angiograms performed from February 2019 to February 2020 which comprised of 415 (52.4%) inpatients and 377 (47.6%) outpatient procedures. A total of 283 (35.8%) patients underwent PCI which comprised of 147 (51.9%) elective procedures. 129 (87.8%) of elective patients were deemed suitable for SDD by the treating team. Mean age of the cohort was 65.7 ± 11.0 years with majority of patients being male (79.8%). Table 1 shows the baseline clinical characteristics and procedure details for the SDD patients. Pre-procedure functional testing with myocardial sestamibi perfusion imaging or exercise stress testing was performed in 27.1% (*n*=35) of patients; 24.8% (*n*=32) of patients underwent anatomical testing with CTCA prior to PCI. PCI was performed via radial access in majority of patients (89.9%). Fractional flow reserve (FFR) was used in 19.4% and imaging guidance with intravascular ultrasound (IVUS) or optical coherence tomography (OCT) was used in 7.0% of cases. About 146 lesions underwent PCI which comprised of: left main (1.4%); LAD (48.6%); diagonal (3.4%); LCX (17.8%); RCA (26.7%); intermediate (0.7%) and PDA (1.4%). Most patients had type C lesions (60.3%; including 4 CTOs)

Table 1. Patient baseline characteristics and procedural details.

	SAME DAY DISCHARGE (N=129)
Age (mean ± SD), years	65.7 ± 11.0
Male gender	103 (79.8%)
Diabetes	50 (38.8%)
Hypertension	63 (48.8%)
Dyslipidaemia	21 (16.3%)
Current smoker	16 (12.4%)
Atrial fibrillation	9 (7.0%)
Previous PCI	33 (25.6%)
Previous coronary artery bypass graft (CABG)	2 (1.6%)
Non-invasive test	
CTCA	32 (24.8%)
Sestamibi	7 (5.4%)
Stress test (EST, ESE)	28 (21.7%)
Vascular access	
Radial	116 (89.9%)
Distal radial	2 (1.6%)
Femoral	11 (8.5%)
Use of FFR	25 (19.4%)
Use of intracoronary imaging, IVUS/OCT	9 (6.9%)
Lesion type	
A	7 (4.8%)
B	51 (34.9%)
C	88 (60.3%) including 4 CTOs
Target vessel	
Left main	2 (1.4%)
LAD	71 (48.6%)
Diagonal	5 (3.4%)
LCX	26 (17.8%)
RCA	39 (26.7%)
Intermediate	1 (0.7%)
PDA	2 (1.4%)

Abbreviations: CTCA, computed tomography coronary angiogram; CTO, chronic total occlusion; ESE, exercise stress echocardiography; EST, exercise stress test; IVUS, intravascular ultrasound; LAD, left anterior descending artery; LCX, left circumflex artery; OCT, optical computed tomography; PCI, percutaneous coronary intervention; PDA, posterior descending artery; RCA, right coronary artery.

followed by type B (34.9%) and type A (4.8%). Drug eluting stents (DES) were used in all PCI cases.

Characteristics of admitted patients is shown in Table 2. About 18 (12.2%) patients were admitted post PCI. The patients who stayed overnight in hospital stayed for median of

Table 2. Characteristics of admitted patients.

	ADMITTED POST PCI (N=18)
Age (mean ± SD), years	73.8 ± 11.5
Male gender	11 (61.1%)
Diabetes	7 (38.9%)
Hypertension	9 (50.0%)
Dyslipidaemia	1 (5.6%)
Atrial fibrillation	2 (11.1%)
Previous PCI	5 (27.8%)
Vascular access	
Radial	15 (83.3%)
Femoral	3 (16.7%)
Lesions (n=19)	
A	1 (5.3%)
B	5 (26.3%)
C	13 (68.4%)
Target vessel	
Left main	1 (5.3%)
LAD	11 (57.9%)
Diagonal	1 (5.3%)
LCX	2 (10.5%)
RCA	4 (21.1%)
Reasons for admission	
Age ≥80 year	6
Non-English speaking or lack of support	4
Persistent chest pain post procedure	2
Coronary artery dissection for observation	2
Side-branch occlusion	1
Observation post POBA	1
Failed PCI for rotational atherectomy	1
Observation post shockwave lithotripsy	1

Abbreviations: LAD, left anterior descending artery; LCX, left circumflex artery; PCI, percutaneous coronary intervention; RCA, right coronary artery.

1.2 day. Patients admitted post PCI included: 2 coronary artery dissections requiring second stent; 2 with post procedure chest pain requiring observation; 1 side branch occlusion admitted for glycoprotein Iib/IIIa inhibitor infusion; 1 post plain balloon angioplasty (POBA) and 1 post Shockwave intravascular lithotripsy. One patient required admission for

Table 3. 30 Days clinical outcomes.

	SAME DAY DISCHARGE (N= 129) (%)
Major adverse cardiac events (MACE) at 30 days	0 (0)
Bleeding	0 (0)
Vascular complications	1 (0.8) (radial artery occlusion)
Stroke	0 (0)
Myocardial infarction	0 (0)
Re-hospitalisation	
Cardiac chest pain	1 (0.8)
Heart failure	2 (1.6)
Non-cardiac chest pain	4 (3.1)
Hip pain	1 (0.8)
Hydronephrosis	1 (0.8)
Backpain	1 (0.8)

staged rotational atherectomy. About 10 (55.6%) patients were admitted due advanced age and other social and non-medical reasons.

Clinical outcomes

Primary outcome occurred in zero patients at 30-day follow-up. Secondary outcome occurred in 11 (8.5%) patients: 10 (7.8%) patients had a re-hospitalisation within 30 days. Mean time to rehospitalisation was 6.5 days. Table 3 Shows the 30-day clinical outcomes. One patient underwent repeat angiogram at another facility for ongoing chest pain but did not require further intervention. One patient developed radial artery occlusion which was managed conservatively.

Cost

We included cost analysis of diagnostic angiogram, PCI, ECGs, pathology tests and estimates of monitored beds for admission. Costs were calculated per patient in addition to those of the cohort of elective patients that underwent PCI (n=129). Figure 1 illustrates the total cost for the SDD cohort (n=129) compared to the potential costs if the same cohort were admitted overnight or had an admission followed by staged PCI. For a patient that was eligible for SDD, this equated to \$2090 per patient compared to \$4440 (112% higher) per patient for overnight admission and \$4700 (125% higher) per patient for staged PCI and an overnight stay ($P=.04$). The total costs for the cohort (n=129) for each of the 3 scenarios equates to \$269 610 for SDD; \$303 150 for overnight admission and \$606 300 for staged PCI with an overnight admission.

Discussion

The key findings of this study are that: (1) Same day discharge (SDD) following elective coronary angiography and percutaneous coronary intervention is safe; (2) Can be performed in the vast majority of patients (approaching 90%); (3) Is associated with significant cost savings; (4) Can be the standard of care despite a patient cohort with high procedural and anatomical risk, in a hospital and catheter laboratory with a new PCI programme.

Elective PCI has become more prevalent and continues to represent a large number of PCI procedures globally. Expansion of PCI procedures to facilities without cardiothoracic surgical backup has significantly contributed to the increase in elective procedures. Advances in PCI including radial access, drug eluting stents (DES), imaging with IVUS and OCT and coronary physiology assessments have led to increased safety of the procedure. There have been multiple studies demonstrating the safety and feasibility of SDD. A large cohort of patients from observational studies and randomised trials were evaluated for the outcomes of same day discharge versus overnight hospitalisation following PCI showing similar rate of MACEs associated with both strategies.¹⁰ A similar analysis also showed that in selected patients undergoing PCI, same day discharge was not associated with a higher rate of major adverse events and this strategy appeared to be as safe as an overnight admission.¹¹ They also showed that patients who were excluded from same day discharge following PCI had worse short- and long-term outcomes however these likely represented a higher-risk group. More recently, a review of 8 randomised control trials showing that mortality, myocardial infarction (MI) and major adverse cardiac events (MACEs) were not significantly different between same day discharge versus overnight stay following PCI.¹⁷

Despite the demonstrated safety of SDD, the practice varies considerably with limited consensus regarding accepted criteria. Several characteristics of the patients that have been included in studies of same-day discharge include: stable angina or low risk acute coronary syndrome (ACS); no significant comorbidities; predominantly single-vessel PCI with no procedural complications and observation for a period of time post-procedure before discharge. Other criteria that have been considered when selecting appropriate patients for same-day discharge included adequate patient social support and access to routine and urgent follow-up. Some studies have suggested higher risk patients undergoing PCI might also be discharged the same day, including patients with non-ST-segment elevation myocardial infarction.¹² Patients converted to overnight admission from previous studies have been as a result of procedural complications, significant co-morbidities, lack of social support or advanced age.

We demonstrate the feasibility of SDD with most patients (88%) deemed suitable for same day release with no MACE events at 30 days follow-up. This is greater than previous

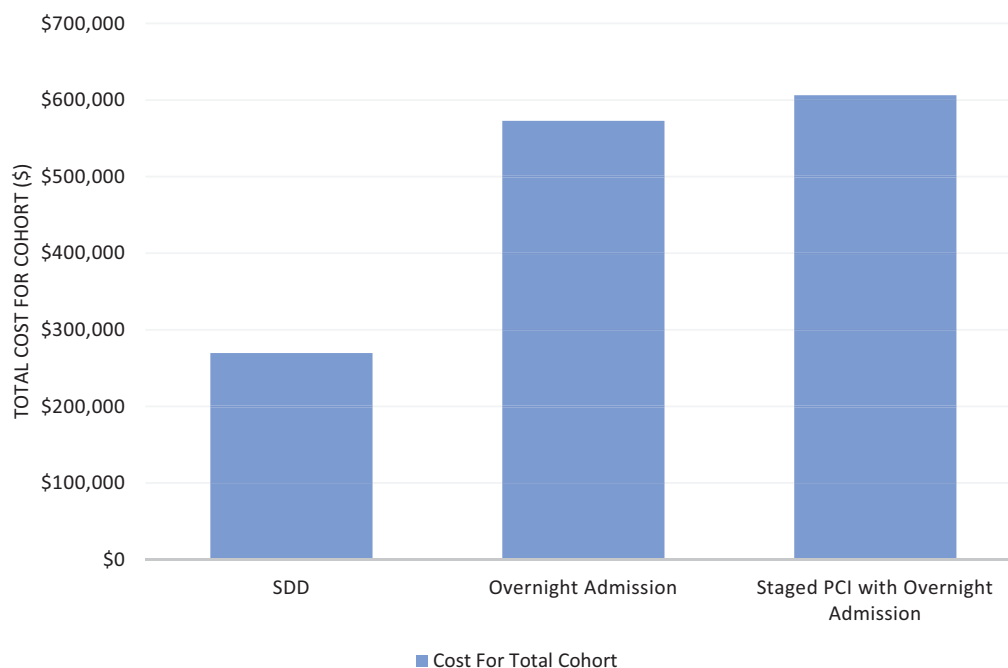


Figure 1. Cost of PCI for total cohort (n=129) comparing potential scenarios. Calculated total cost for the SDD cohort (n=129) compared to the potential costs if the same cohort were admitted overnight or had an admission followed by staged PCI. Abbreviations: PCI, percutaneous coronary intervention; SDD, same day discharge.

studies with rates of SDD ranging from 65% to 80%.^{6,9,12} Furthermore, 56% of our patients admitted overnight were due to advanced age and other social reasons. Only 3 patients were admitted overnight due to procedural complications. There is great heterogeneity regarding reasons for admission post PCI in the literature. These included abrupt vessel closure, stent thrombosis, access site complications, non-access site bleeding, heart failure, contrast reactions and arrhythmia.^{23,24} Interestingly, anatomical criteria such as lesion complexity and stent length did not correlate with hospital admission.⁶ We have found this to be consistent with our cohort with 60.3% of lesions being type C lesions; with 2 left main interventions as well as 4 chronic total occlusion interventions. Consequently, the Society for Cardiovascular Angiography and Interventions (SCAI) guidelines have been updated to include procedural and patient criteria for discharge rather than only patient and anatomical factors.²⁵

There have been a number of barriers to SDD that have led to slow adoption in many centres. One common barrier was the impact of re-hospitalisation and the potential of adverse events such as infection and deconditioning.¹² In our cohort, 7.8% of patients were hospitalised within 30 days with the mean time less than 1 week after discharge. A significant number (70%), however were emergency department presentation for non-cardiac chest pain that were discharged on the same day. This did not translate to any MACE events. Furthermore, there is growing evidence supporting increased patient preference for recovery at home.^{26,27} Medico-legal concerns have also been a potential barrier to SDD internationally. An analysis of cardiac catheterisation-related litigation in

the United States and found that most of the legal risk is a direct result of adverse events during the procedures, with the outcome of death most likely to result in a lawsuit.²⁸ Other barriers relating to procedural risks such as stent thrombosis and vessel dissection/closure were low, with the few patients in our cohort not requiring any intervention. Clinical judgement remains critical in decision making and if there are concerns about an adverse outcome or a suboptimal PCI result, the patient should not be discharged home. Furthermore, patient education and medication review remain critical and should be reinforced in follow-up.

Costs analysis

In addition to safety and feasibility, significant economic benefit has the potential to improve adoption of SDD. We have demonstrated estimated cost savings of AUD \$2350 per patient with similar cost effectiveness in previous international studies.¹⁷⁻¹⁹ Significant cost implications have also resulted from the adoption of trans-radial approach as in 89.9% of our cohort. A cost saving of \$1.8 million annually in hospitalisation costs using a radial approach was demonstrated.¹⁶ Our institution has implemented a streamlined approach for elective PCI with all patients pre-loaded with aspirin and a P2Y12 receptor inhibitor pre-procedurally to facilitate progression to PCI. This has not negated the cost benefits within our institution. A significant number of patients also underwent FFR assessment (19.4%) with 7.0% use of coronary imaging with either IVUS or OCT. While cost analysis of these modalities is beyond the scope of this study, A study demonstrated a cost saving of

AUD \$1200 in the Australian public sector with FFR use for intermediate lesions.²⁹ There is potential for greater cost saving in the future as reimbursement for these technologies becomes more streamlined. As the number of elective PCIs continue to increase in the Australian population, an SDD strategy leads to greater efficiency and significant cost savings.

Limitations

Our study has several limitations, namely this is a small non-randomised cohort of a single centre and a single cardiac catheterisation lab experience of the first 12 months of PCI. Nevertheless, this demonstrates the feasibility of SDD to larger laboratory settings. Furthermore, not all information relevant to deciding on an SDD or an overnight admission was available; in particular, data regarding hospital policies, clinician preferences and patient preferences were not included. The follow up in our study was limited to 30 days post procedure and longer follow up with a larger cohort would assist in further establishing the feasibility of SDD, however, major differences between SDD, overnight stay or staged PCI would not be expected to persist beyond this period therefore we feel that the results are durable over a longer period. Finally, our study illustrates the cost effectiveness of an SDD strategy compared to the routine practice of overnight admission.

Conclusions

In our experience, SDD is safe and feasible in the majority of patients that have elective PCI. SDD significantly reduces the total cost and hospital stay of patients facilitating efficient health service delivery and resource utilisation.

Disclosures

Manuscript abstract was previously presented as an electronic poster at a national conference. As first author I have rights to publish this manuscript.

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