Am J Cardiovasc Dis 2023;13(2):32-42
www.AJCD.us /ISSN:2160-200X/AJCD0147577

Review Article

An exploration of the early discharge approach for low-risk STEMI patients following primary percutaneous coronary intervention

Nicole Broughton[1], Katrina Comer[3], Oliver Casey-Gillman[3], Lizze Moore[3], Sotiris Antoniou[4], Riyaz Patel[3], Sadeer Fhadil[4], Paul Wright[4], Muhiddin Ozkor[2,3], Oliver Guttmann[2,3], Andreas Baumbach[1,2,3], Andrew Wragg[2,3], Ajay J Jain[2,3], Fizzah Choudry[1,2,3], Anthony Mathur[1,2,3], Krishnaraj S Rathod[1,2,3*], Daniel A Jones[1,2,3*]

[1]Centre for Cardiovascular Medicine and Devices, Willian Harvey Research Institute, Queen Mary University of London, London EC1A 7BE, UK; [2]Barts Interventional Group, Barts Heart Centre, Barts Health NHS Trust, London EC1A 7BE, UK; [3]Department of Cardiology, Barts Heart Centre, Barts Health NHS Trust, London EC1A 7BE, UK; [4]Department of Pharmacy, Barts Heart Centre, Barts Health NHS Trust, London EC1A 7BE, UK. [*]Equal contributors.

Received November 7, 2022; Accepted March 17, 2023; Epub April 15, 2023; Published April 30, 2023

Abstract: Recently, there has been growing interest in the early discharge strategy for low-risk patients who have undergone primary percutaneous coronary intervention (PCI) to treat ST-segment elevation myocardial infarction (STEMI). So far findings have suggested there are multiple advantages of shorter hospital stays, including that it could be a safe way to be more cost- and resource-efficient, reduce cases of hospital-acquired infection and boost patient satisfaction. However, there are remaining concerns surrounding safety, patient education, adequate follow-up and the generalisability of the findings from current studies which are mostly small-scale. By assessing the current research, we describe the advantages, disadvantages and challenges of early hospital discharge for STEMI and discuss the factors that determine if a patient can be considered low risk. If it is feasible to safely employ a strategy like this, the implications for healthcare systems worldwide could be extremely beneficial, particularly in lower-income economies and when we consider the detrimental impacts of the recent COVID-19 pandemic on healthcare systems.

Keywords: STEMI, early discharge strategy, primary PCI, length of stay

Introduction

STEMI describes a type of acute myocardial infarction, blood flow to the myocardium is obstructed which leads to necrosis or damage to the heart muscle. Typically, the clinical features of STEMI are chest pain, dyspnoea, diaphoresis, nausea, dizziness and feelings of anxiety. As per the most recent guidelines issued by the European Society of Cardiology (ESC), the occurrence of a STEMI is confirmed in patients who present with chest pain and/or other symptoms associated with ischaemia if ST-segment elevation is observed in at least two neighbouring leads on a 12-lead electrocardiogram (ECG) [3]. Specifically, the criteria can include the presence of a new left bundle branch block or persistent, new ST elevation in two consecutive leads of ≥1 mm in all leads - apart from V2 and V3 in which the cut off points are; ≥2 mm for men ≥40, ≥2.5 mm for men <40 and ≥1.5 mm for all women [4]. An example of how elevation of the ST-segment appears on an ECG is presented in **Figure 1**. Prompt reperfusion is paramount when treating STEMI in order to ensure the best patient outcomes, cardiac centres across the UK have been able to achieve this largely due to the introduction of PCI alongside the administration of improved fibrinolytic therapies.

Primary PCI and fibrinolysis are currently the two main reperfusion therapies for STEMI. Primary PCI has the most efficacy, it has been found to significantly reduce mortality, reinfarction and stroke compared to fibrinolysis so is

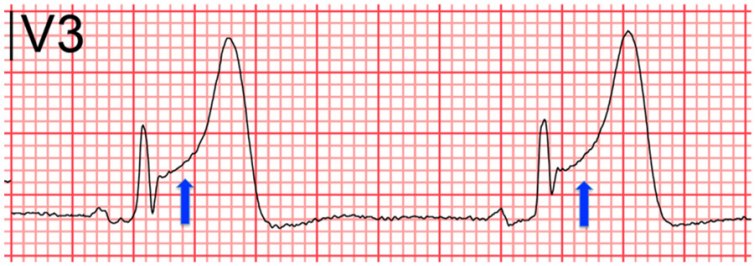

Figure 1. An ECG displaying ST-segment elevation. An ECG of a patient with an elevated ST-segment, as indicated by the arrows - the presence of this is used to confirm the occurrence of STEMI.

therefore the preferable treatment [3]. ESC guidelines dictate that primary PCI is indicated when it can be performed by experienced professionals within the 12-hour window from when STEMI and ischaemic symptoms begin [3]. It is important to consider that worldwide it isn't logistically possible for all low-risk patients to easily access PCI, despite it being preferable it isn't always available, so it isn't always needed. In these cases where PCI can't be given in a timely manner, fibrinolysis can be given as an alternative or given until PCI can be performed, although this is not as effective as PCI [5]. However, there isn't evidence to suggest these low-risk patients would be suitable for the proposed early discharge approach.

In-hospital mortality of unselected STEMI patients ranges between 4 to 12% and 1-year mortality is around 10%, which reflects improvements in the prognosis of STEMI, but mortality is still considerable [3]. Improvements in treatment, along with a strive to keep door to balloon time under 90 minutes is responsible for the significant reduction in the mortality and morbidity associated with STEMI over the years [6]. This has been a driving force behind a growing area of interest in research as of late - the potential to reduce the length of stay (LOS) in hospital of low-risk STEMI patients following primary PCI. According to ESC guidelines its suggested LOS ought to be decided based on the patient's circumstances and if they're considered to be at low risk of complications, it could be appropriate to discharge within 2-3 days [3]. The optimal amount of time before discharge has currently not been established, with no direct guidance therefore contributing to the variation seen in discharge times [7]. However, recently various studies have been culminating evidence that demonstrates LOS can be made shorter, gathering data to show it's safe and effective for this to be minimised to potentially 24-48 hours in low-risk individuals. Early hospital discharge (EHD) in this instance has potential to be valuable to healthcare services globally, improving patient outcomes and providing economic benefits - which is currently of particular significance as we emerge from the COVID-19 pandemic which has mounted remarkable pressures on healthcare systems. Nevertheless, patient safety is of utmost importance and considering this alongside other potential disadvantages of EHD such as the lack of opportunity for healthcare professionals to educate patients, thorough investigation of 24-48 hour LOS is needed before widespread application. This essay will critically investigate the current body of research to determine whether for some patients a 24-48 hour LOS after primary PCI is feasible - exploring the potential advantages, disadvantages and deficits in evidence alongside an examination of the potential factors that could form a criterion to help discern which patients can be considered low-risk.

Advantages of early discharge from hospital of low-risk STEMI patients following primary PCI

Discharging low-risk STEMI patients from hospital earlier following primary PCI has several benefits for both patients and healthcare systems, and there is a growing body of supporting evidence backed by the findings from numerous studies.

Firstly, there are economic benefits of implementing a protocol which facilitates EHD of low-risk STEMI patients. Primary PCI has already been proven to be a cost-effective way to treat STEMI, producing better health outcomes and reducing healthcare costs in the long-term versus other therapies like thrombolytics [8]. However, STEMI treatment via primary PCI imposes an extra strain on resources within healthcare systems - a substantial amount of this pressure can be attributed to the LOS in hospital post-primary PCI [9]. Long hospital stays increase costs and can be an inefficient

use of resources and bed capacity. A nationwide study found that very short (1-2 day) LOS of STEMI patients lead to around a 5% fall in overall costs when compared to the traditionally longer (≥3 days) LOS following primary PCI [10]. Similarly, an observational study reported cost savings equivalent to 400 bed-days in a cardiac care unit between the April 2020-June 2021 study period - a consequence of implementing their early discharge pathway, which shortened the overall median LOS from 3 days to 2 days [11]. Therefore, alongside financial and resource savings - earlier discharge of patients also increases bed availability for other patients requiring care, allowing for improved patient turnover in cardiac centres which face high demand. Achieving optimal and efficacious delivery of care is important, particularly following the COVID-19 pandemic which stretched healthcare systems to their limits. To achieve more cost- and resource-efficient care, healthcare systems could employ an early discharge strategy, whilst using technology such as smartphone apps designed to facilitate follow-up that are reliable and easily accessible to patients, and use refined risk-scores to save time determining patients considered low risk. Also, earlier discharge could have great financial outcomes for healthcare systems within lower-income economies - meaning the saved money and resources can be spent in other areas of healthcare that require it [12].

In addition, shorter LOS in hospital is preferred by patients and is likely to boost patient satisfaction. Longer periods of time in hospital can be accompanied by negative impacts on a patient's physical and psychological wellbeing. For example, the more time a patient spends in hospital the more delay there is to their complete recovery and return to usual daily life. Along with this, longer LOS can take an emotional toll on many patients - evoking feelings like stress, powerlessness and loneliness [13]. If early discharge was routinely implemented appropriately for low-risk STEMI patients, they could recover surrounded by their support system in a comfortable and familiar environment - making their return to normality sooner. Evidence investigating and directly supporting increased satisfaction from early discharge after STEMI is scarce. In one instance, a small-scale study used a Likert-scale to measure patient satisfaction of 45 low-risk patients with acute coronary syndromes and found 73% of patients were fully satisfied with early discharge, 18% were almost satisfied but 2% would've preferred a longer stay [14]. Albeit a small proportion of patient's who felt their discharge was too premature, this could become a significant issue amongst larger samples of patients. The fact some patients prefer to stay for longer periods in hospital could be explained by many reasons, for instance the absence of a support system at home, health anxiety or previous negative experiences leading some patients to feel safer in hospital. Also, patients with comorbidities that are familiar with their condition may feel from experience they require longer stays. Further studies could provide more insight into these reasons, therefore medical professionals could confidently reassure these patients whilst providing them the support they need if EHD is beneficial and suitable for them. However, in a recent study of 600 STEMI patients discharged early following primary PCI, it was found 85% were 'satisfied' or 'very satisfied' with their care [11]. The fact this study's protocol had established a robust follow-up pathway is likely to have been critical to this, facilitating adequate patient support post-discharge. Investigating satisfaction in future studies will reveal if there's a consensus for high patient satisfaction when carrying out an early discharge strategy, and if dissatisfaction can be avoided with the use of effective follow-up programmes.

Furthermore, findings concerning safety from studies that implement early-discharge for low-risk STEMI patients have been positive so far. A meta-analysis involving a combination of seven randomised controlled trials & observational studies found early discharge (≤3 days) of low-risk STEMI patients to be safe, also compared to late (>3 day) discharge they did not find any significant differences in terms of mortality, readmissions or major adverse cardiac events (MACE) [15]. Additionally, a meta-analysis of readmissions of STEMI patients after primary PCI found significantly reduced readmissions in the shorter LOS (1-2 day) cohort - which further contributes to the lower costs associated with early discharge and supports its safety [10]. Further supporting this, it has been reported that in a majority of cases complications occur by 24 hours, suggesting it's unlikely they would occur after early discharge [16]. For

instance, in an observational study involving 2980 STEMI patients of which 60 patients experienced complications - 53 of these had occurred by 24 hours [17]. The data from observational studies seem to support that early discharge leads to better health outcomes i.e., reduced mortality and adverse events compared to longer stays, but this hasn't been reflected in randomised controlled trials so further evidence is needed to determine this [15]. Importantly, an increase in the rate of MACE has not been found to be linked to low-risk patients being discharged early, using observational data collected nationwide [18]. Ultimately, ensuring patient safety is a top priority and so far, the data appears to support this when low-risk patients have been carefully selected.

Another advantage of shorter LOS of low-risk STEMI patients is that this would reduce the risk of patients contracting a hospital-acquired infection. Hospital-acquired infections (HAIs) are those which typically emerge >48 hours after admission and encompass various types of infection such as catheter-associated urinary tract infections and pneumonia [19]. There's a limited number of studies examining the effects and incidence of HAIs in STEMI patients following primary PCI. Despite this it's evident that HAIs, particularly those which affect the respiratory system, are associated with poorer clinical outcomes in STEMI patients and higher mortality [20]. The incidence of HAIs in STEMI patients after primary PCI varies between studies, for example one single-centre study found incidence of 11.1% whereas another which only sampled patients over 80 found incidence as high as 30% [21, 22]. It's important to highlight that the risk of contracting a nosocomial infection is multifactorial, with time spent in hospital being just one of these factors. As higher-risk patients are more likely to contract nosocomial infection for multiple reasons including age and pre-existing comorbidities, it's difficult to predict to what extent reducing LOS in lower-risk patients would have on the incidence of HAIs in STEMI patients following primary PCI. However, albeit more uncommon in lower-risk patients - if the detrimental impacts of HAIs are considered such as those affecting economics and patient health, reducing the risk of HAIs should not be underestimated as a benefit of shorter LOS. For instance, patients with HAIs consequently need longer stays in hospital which utilises more resources, decreases bed capacity and increases costs [22]. Reducing the risk of nosocomial infection transmission has been of great interest during the COVID-19 pandemic, the pressures of the pandemic have been a significant motivator to investigate earlier discharge times. Following this, a reduction in HAI risk has been reflected in recent EHD studies, namely Rathod et al reported that no patients following their early discharge pathway contracted COVID-19 whilst in hospital compared to a potential but not directly confirmed 7.5% of those under standard care [11]. Along with the fact that HAIs can lead to complications and delay a patient's recovery, a reduction in HAI risk is an attractive benefit of reducing the amount of time low-risk STEMI patients spend in the hospital environment after primary PCI.

To summarise, delivery of more cost- and resource-efficient care, increasing patient happiness, reducing HAIs and evidence of positive health outcomes from multiple observational and randomised controlled studies suggest that implementing an early discharge protocol in the standard care pathway of STEMI is very likely to be worthwhile. It's important to highlight that the majority of the studies supporting early discharge demonstrating its potential benefits tend to share the same pitfalls whereby they're typically small, single-centre studies. Larger scale, multi-centre studies will be required, but the former have set the foundations for such studies to take place.

Disadvantages and challenges of early discharge of low-risk STEMI patients following PCI

Despite the prospective benefits associated with earlier discharge, there are potential disadvantages/challenges to be considered if EHD of low-risk STEMI patients is eventually to be made standard practice.

Firstly, there are limitations to the current evidence used to support early discharge. As previously mentioned, most of the studies sample sizes are relatively small with therefore reduced statistical power - making it difficult to safely generalise these findings before larger, multi-centre studies are undertaken. Also, the various observational studies on early discharge can be vulnerable to bias. Some studies may

have bias if participants are lost to follow-up or alternatively if they lack randomisation, gain a vulnerability to selection bias [15]. It has also been highlighted that there's potential for self-selection bias within observational studies, patients were likely to elect themselves for standard discharge versus early if they were given a poorer prognosis [11]. In addition, there're limitations of meta-analyses of randomised controlled trials as they combine studies not only with differing follow-up periods but also the ways in which low-risk patients were selected and the LOS for early discharge was not always consistent [23]. Other elements of early discharge will also require further investigation, for instance how it can translate into other healthcare settings besides cardiac centres and the compliance to and success of follow-up programmes i.e., virtual vs in-person.

An aspect of patient care that will require particular attention if early discharge of STEMI patients is to become routine is sufficient follow-up and care provided after discharge from hospital. ESC guidelines currently advocate for suitable follow-up and early rehabilitation to be put in place if a low-risk STEMI patient is to be discharged after 48-72 hours [3]. The fact that short LOS in hospital doesn't easily allow for the delivery of important parts of patient care such as education of patients, rehabilitation and drug titration has been brought to attention [24]. An organised follow-up programme delivered by way of a multidisciplinary team may be most suitable, similar to what has been successfully utilised in a recent study by Rathod et al which found high rates of patient satisfaction along with low mortality and MACE rates after early discharge [11]. Like Rathod et al, Marbach et al also include a structured follow-up in their protocol for early discharge - both use technology to deliver follow-up which could be a more cost-efficient and convenient way to do so [25]. Further investigation into effective follow-up for STEMI patients discharged early would be ideal. This is because it will enable efficient assessment of symptoms, review of medication and necessary rehabilitation post-discharge alongside provision of advice on prevention strategies [3]. These factors are all important to patient recovery, satisfaction and improved health outcomes in the long-term thus emphasising the importance of adequate follow-up in conjunction with EHD.

Furthermore, the issue of safety needs to be considered thoroughly, there must be strong supporting evidence gathered to ensure this and allow for the implementation of routine early discharge of low-risk STEMI patients. As indicated in the advantages section, the findings as of late seem promising in terms of low mortality and MACE rates of carefully selected patients after early discharge [11, 15, 26]. If this is found to be replicable within larger sample sizes, this would increase generalisability of these findings and confidence within them. MACE refers to various conditions including acute heart failure, reinfarction, arrhythmias and unstable angina that can occur post primary PCI. Shorter stays in hospital mean less time for observation and so there's a chance adverse events could occur post-discharge, potentially putting patient health at risk. It's been demonstrated that the likelihood for MACE to occur in patients classed as 'low-risk' is small, particularly after 24 hours, for instance in a study of STEMI patients in a day 70% of total deaths and MACE events had happened and by 2.7 days this had reached 95% [16]. Despite this chance being very low, it still exists - therefore the use of a method that is as accurate as possible at predicting if it is safe to discharge a patient early will be needed to guide physicians' decisions. This also further emphasises the importance of patient follow-up and education so that in the rare cases these events do occur in early-discharge patients, they can be treated efficiently and potentially detected earlier. A finding that should be brought to attention is that Jang et al reported from their nationwide database analysis that patients in a group with anterior-wall (AW) STEMI that had been discharged early had higher 30-day mortality than those with an AW STEMI who had stayed in hospital for at least 3 days [10]. This could question whether patients with AW STEMI require a minimum LOS or further investigation to determine their risk of complications - however it's not stated how these patients died so it's unclear if deaths were related to complications after STEMI/primary PCI or unrelated conditions and only deaths upon readmission were included [10, 27]. Although this finding in one study shouldn't overcast the safety of early discharge demonstrated in multiple studies, there is room for further investigation of this subgroup for more information on safety. Also, depending on which

Table 1. The Zwolle Risk Score for ST-elevation myocardial infarction risk stratification

Killip Class	Points
1	0
2	4
3-4	9
TIMI Flow Post	
3	0
2	1
0-1	2
Age	
<60	0
≥60	2
3-Vessel Disease	
No	0
Yes	1
Anterior Infarction	
No	0
Yes	1
Ischaemic Time	
≤4 hours	0
>4 hours	1
Total Score	16

A table of the Zwolle Risk Score which can be used to assess risk in ST-elevation myocardial infarction patients - and therefore determine their suitability for early discharge. TIMI flow post means the TIMI flow post-procedure. This figure has been created based on information obtained from [1, 2].

risk score is used this may already be accounted for as some do consider whether the infarction occurred anteriorly e.g., Zwolle risk score [2].

Establishing safety goes hand-in-hand with another challenge of implementing early-discharge protocols for low-risk STEMI patients, which is coming to a consensus and refining what factors are the most important to determine if a patient is low-risk. This would allow for more standardisation and a reduction in the amount of variation between when early discharge is carried out, as currently this can differ depending on the cardiac centre and physician [7]. Larger scale, multi-centre studies in different settings will partially help to facilitate this and deepen understanding of what factors are most important to put a patient at high risk for adverse events and why. A criterion that is simple, reliable and generalisable is needed. Various researchers have established and utilise various scoring systems to calculate risk, the majority of which share some common contributing factors - this includes the Zwolle Risk Score and CADILLAC risk score [2, 28]. An example of the Zwolle Risk Score and how it is used to 'score' and therefore stratify a STEMI patient's risk is seen in **Table 1** [1]. ESC guidelines mention that scores can be utilised to determine whether a patient is low-risk when considering early discharge, but no single criteria is given preference over others at this time, the guidelines namely include the Zwolle Risk Score and Primary Angioplasty in Myocardial Infarction (PAMI-II) criteria [3]. The various factors that could contribute to a patient's risk of MACE and mortality which determine if a patient is low-risk and thus safe to discharge early will be explored in the following section.

To summarise, a lack of a refined and agreed upon risk score, the limitations of the current research available such as small sample sizes and bias, a lack of evidence to confirm the safety of EHD and the need for adequate follow-up procedures to ensure education and successful recovery of patients are the main challenges facing EHD for STEMI currently. Primarily, it's down to healthcare professionals to decide on an individual basis when they feel is the optimal time to discharge a patient. In the future, if this is guided by an agreed-upon and effective criterion backed by evidence, early discharge could be routinely carried out safely. Safety, follow-up, agreement on how to identify low-risk patients along with findings from further research studies will be important considerations before implementing shortening of LOS of low-risk STEMI patients following primary PCI on a large scale.

What factors impact if a patient is suitable for early discharge?

Determining how to identify which patients can be considered low-risk reliably, safely and efficiently is imperative for early discharge to be implemented in healthcare systems. Therefore, it must be investigated and established what factors are most important and why. As mentioned before, some studies investigating early discharge build their own criterion to use when classifying low-risk STEMI patients and there are also various risk scores that have already been established. There are some predictors

for MACE and mortality that are commonly used and there tends not to be drastic differences between scores - which begs the question as to how we should refine this. Here, some of these factors will be discussed.

Age has been consistently recognised as a prominent risk factor to predict for MACE and mortality following STEMI and is incorporated into the majority of current risk scores, typically individuals that are ≥60 are considered to be at higher risk - with age being positively correlated with risk [2, 29]. Elderly patients often present with atypical symptoms, consequently increasing the chance of complications and heart failure as lessening the extent of damage caused by STEMI is best facilitated through timely diagnosis and reperfusion [3]. Multiple studies have observed that comorbidities are more prevalent amongst older patients including diabetes, hypertension, prior myocardial infarction and heart failure - therefore these individuals are put at a higher risk for complications and deciding treatment is increasingly complex [29, 30]. With increasing age, higher risk of bleeding and reduction in renal function also contributes to this [3]. As expected, this is reflected in studies trialling early discharge, with older age being common amongst patients in the longer LOS cohorts [11]. However, we must consider that for some uncomplicated older patients early discharge could be appropriate. In view of these findings, it supports that incorporating age into STEMI risk scores is justified and important to be considered - with increasing age making it less likely that early discharge will be safe or beneficial for a patient due to risk of complications. Further studies that stratify subgroups of older age patients may be helpful, particularly as it has been suggested that there's underrepresentation of the elderly in STEMI trials and often there's grouping together of all patients over 60 which makes it difficult to identify differences [29].

STEMI patients with fewer or no comorbidities are more likely to be eligible for earlier discharge following primary PCI - notable comorbidities mentioned in ESC guidelines include diabetes and renal failure [3]. A study analysing renal function in 5244 STEMI patients that took part in the APEX-AMI trial found patients with pre-existing renal dysfunction angiographically and clinically had less favourable outcomes [31]. Considering an approximated 30-40% of patients with acute coronary syndromes have an estimated glomerular filtration rate classed as renal dysfunction, <30 ml/min/1.73 m^2, renal function should be considered as a criterion candidate [32]. These patients are also more likely to have delayed diagnosis which increases their risk of accumulating more myocardial damage, as they're less likely to present with a common symptom of STEMI - chest pain, and their ECG may not show classic signs [32]. Similarly, diabetic patients have also been observed to present atypically along with an increased chance of complications and mortality [3]. It's less likely patients with comorbidities will be suited to earlier discharge due to these increased risks of complications which could occur following discharge. However, further exploration of comorbidities and STEMI outcomes is warranted i.e., what comorbidities hold the greatest significance in order to be incorporated into a risk score or could other factors account for these differences? Diabetes and renal dysfunction are not the only comorbidities that are important to investigate, others like anaemia and hypertension must be considered too or maybe a more general negative stance towards significant comorbidities and risk should be taken. Developing our understanding of this will allow for further refinement of an early discharge criterion, as there's currently inconsistency between scores - for instance as seen in **Table 2** the Zwolle score doesn't directly address comorbidities at all, PAMI includes diabetes and CADILLAC includes renal function [28].

Procedural variables are also frequently used to judge patient risk. Killip class has been shown as a valid way to stratify risk and is commonly included within risk scores and trials employing early discharge strategies - evidence indicates this is done rightfully so, as patients in upper categories have higher degrees of heart failure hence worse prognosis short-term [34]. Left ventricle ejection fraction (LVEF) can be used to assess for systolic dysfunction of the left ventricle, Halkin et al argue baseline LVEF should be present in all risk scores and is the strongest predictor of patient survival - with LVEF <40% putting a patient at higher risk for complications and heart failure [28]. Whether a patient possesses single or multi - vessel disease is another indicative factor, reflected in

Table 2. A table to compare three validated risk scores for STEMI

Risk Score	How was it developed?	What variables are included?
Zwolle Risk Score [2]	Based off of analysis of 1791 patients from a primary PCI registry	Age, Killip class, triple vessel disease, ischaemia time, anterior infarction, TIMI flow post-PCI
CADILLAC Risk Score [28]	Based off of data from two studies - the CADILLAC trial (2082 patients) and Stent-PAMI trial (900 patients)	Age, Killip class, TIMI flow post-PCI, baseline LVEF, anaemia, triple vessel disease, renal insufficiency
PAMI Risk Score [33]	Based off of 3252 STEMI patients treated with PCI that took part in the multiple PAMI trials	Age, Killip class, diabetes, anterior infarction, left bundle branch block

A table to compare some of the most commonly utilised risk scores for STEMI, information in the table has been sourced from the 3 papers from which the scores originate from [2, 4, 28, 33].

the fact that successfully treated less complex/single - vessel cases are more prevalent in early discharge cohorts [11]. Multi - vessel disease may affect around 40% of STEMI patients, considering that this has been associated with poorer outcomes it could be an important predictor for risk [35]. Thrombolysis in Myocardial ing area of interest in research as of late-PCI can assess procedural success, in a study analysing outcomes in anterior STEMI patients in relation to TIMI flow those in grade 0 to 2 had poorer outcomes compared to those in group 3 and above e.g., 13.9% compared to 6.1% of patients had MACE within 30 days and 7.3% vs 2.2% had cardiac deaths [36]. Establishing that a patient has rhythmic and haemodynamic stability prior to early discharge is integral to ensuring patient safety, there are other routinely and easily assessed variables that can determine this. For example, an absence of any arrhythmia or symptoms of ischaemia along with normal vital signs e.g., heart rate and urine output, is desirable [37]. All of the above are rational ways to identify low-risk patients from those who may require longer stays and observation, it needs to be clarified whether it would be useful to include all of them or rather a select few in a criterion for early discharge.

ESC guidelines highlight that the amount of time or delay that elapses before a patient receives primary PCI and achieves reperfusion has influence on mortality in STEMI, the longer this ischaemic period is the more damage there is to the myocardium [3]. Ischaemic time is made up of multiple components i.e., patient delay, emergency services delay and system delay within a healthcare centre - this period can also dictate the mode of therapy chosen. Total ischaemic time (TIT) of a patient refers to the time from symptom onset to inflation of the balloon, whereas door to balloon (DTB) time refers to arrival in hospital to ballooning and ≤90 minutes is widely believed to be optimal [3]. There are some studies which suggest TIT is superior and more accurate at predicting mortality and size of an infarction over DTB time, however there is still debate over which should be used particularly if ideal DTB time is achieved [38, 39]. Whether this should be included in risk scores is therefore questionable, only the Zwolle score seen in **Table 2** includes ischaemic time, but potentially in other scores this is accounted for by other variables that gauge the damage to and functioning of the heart post-primary PCI.

There are also factors that tend not to appear in risk scores but may still be of importance to consider before a decision for early discharge is made. Rathod et al's study highlights that patients ideally should have appropriate social circumstances and adequate mobility before early discharge, which has sometimes been an overlooked detail in other studies but is key to facilitating smooth patient recovery and delivery of follow-up [11]. Gender differences concerning STEMI outcomes is a contested area, it has been observed women are more likely to present atypically, have higher chances of bleeding and have longer hospital stays [40]. However, there is uncertainty surrounding these differences and it doesn't necessarily warrant inclusion into risk score criterion, as it's unlikely that women innately have worse outcomes than men, but this could be down to the fact that women with STEMI are often older and have comorbidities [3]. Whilst gender may not be significant to include in criterion, mobility and social circumstances should be acknowledged before a patient is discharged early.

It's highly common for predictors of negative outcomes discussed here to be seen together, take for instance that older patients are more likely to have comorbidities - this alongside the

fact there are many variables contributing to risk makes it harder to refine a criterion. However, as previously mentioned there are multiple scores and studies that have validated simple criteria already for early discharge. Even if a criterion becomes widely used, there's always potential for alterations to be made as larger sample sizes are likely to reveal further information. Further research will facilitate the fine-tuning of an easy-to-use criterion which could aid physicians to make their decisions on whether it is appropriate to discharge a patient early after STEMI. This will not be one-size-fits-all as LOS is judged ultimately on an individual basis but would provide the guidance needed to allow for a wider-spread implementation of early discharge after STEMI and decrease the variation currently seen in LOS.

Conclusion

To conclude, a shift towards shortening LOS for low-risk STEMI patients following primary PCI is occurring and evidence indicates this is safe and efficacious thus far. With the support of a structured follow-up programme, carefully selected low-risk STEMI patients could potentially be discharged within 24-48 hours. Implementation of a method like this could significantly improve how we treat STEMI, as patients spend less time in hospital, they have less chance of contracting a hospital acquired infection, hospital resources are conserved, and patient satisfaction is high - facilitating a timely recovery. It must be emphasised that there's still missing information that's required to inform aspects of the early discharge strategy which can be provided by larger, randomised controlled trials. This will be critical in determining optimal timing of discharge in low-risk patients, if this can be safely implemented globally and/or in all healthcare environments and to make subsequent improvements to low-risk patient criterion. Further advances in treatments for STEMI are likely to additionally promote this approach - for instance supersaturated oxygen therapy that can be performed following PCI appears to be able to reduce myocardial damage sustained after STEMI, which therefore could increase the number of patients suitable for early discharge [41]. Healthcare systems endeavour to provide the best care possible efficiently with patient safety at the forefront - and an early discharge strategy for low-risk STEMI patients could help facilitate this.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Daniel A Jones, Department of Cardiology, Barts Heart Centre, St. Bartholomew's Hospital, West Smithfield, London EC1A 7BE, UK. Tel: 02037658707; E-mail: daniel.jones@qmul.ac.uk

References

[1] Kotowycz MA, Cosman TL, Tartaglia C, Afzal R, Syal RP and Natarajan MK. Safety and feasibility of early hospital discharge in ST-segment myocardial infarction - a prospective and randomized trial in low-risk primary percutaneous coronary intervention patients (the safe-depart trial). Am Heart J 2010; 159: 117, e1-6.

[2] De Luca G, Suryapranata H, van't Hof AW, de Boer MJ, Hoorntje JC, Dambrink JH, Gosselink AT, Ottervanger JP and Zijlstra F. Prognostic assessment of patients with acute myocardial infarction treated with primary angioplasty: implications for early discharge. Circulation 2004; 109: 2737-2743.

[3] Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, Caforio ALP, Crea F, Goudevenos JA, Halvorsen S, Hindricks G, Kastrati A, Lenzen MJ, Prescott E, Roffi M, Valgimigli M, Varenhorst C, Vranckx P and Widimský P; ESC Scientific Document Group. 2017 ESC guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: the task force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). Eur Heart J 2018; 39: 119-177.

[4] Thygesen K, Alpert JS, Jaffe AS, Chaitman BR, Bax JJ, Morrow DA and White HD; ESC Scientific Document Group. Fourth universal definition of myocardial infarction (2018). Eur Heart J 2019; 40: 237-269.

[5] Fazel R, Joseph TI, Sankardas MA, Pinto DS, Yeh RW, Kumbhani DJ and Nallamothu BK. Comparison of reperfusion strategies for ST-segment-elevation myocardial infarction: a multivariate network meta-analysis. J Am Heart Assoc 2020; 9: e015186.

[6] Vogel B, Claessen BE, Arnold SV, Chan D, Cohen DJ, Giannitsis E, Gibson CM, Goto S, Katus HA, Kerneis M, Kimura T, Kunadian V, Pinto DS, Shiomi H, Spertus JA, Steg PG and Mehran R.

ST-segment elevation myocardial infarction. Nat Rev Dis Primers 2019; 5: 39.
[7] Karabulut A, Cakmak M, Uzunlar B and Bilici A. What is the optimal length of stay in hospital for ST elevation myocardial infarction treated with primary percutaneous coronary intervention? Cardiol J 2011; 18: 378-384.
[8] Selmer R, Halvorsen S, Myhre KI, Wisloff TF and Kristiansen IS. Cost-effectiveness of primary percutaneous coronary intervention versus thrombolytic therapy for acute myocardial infarction. Scand Cardiovasc J 2005; 39: 276-285.
[9] Newby LK, Eisenstein EL, Califf RM, Thompson TD, Nelson CL, Peterson ED, Armstrong PW, Van de Werf F, White HD, Topol EJ and Mark DB. Cost effectiveness of early discharge after uncomplicated acute myocardial infarction. N Engl J Med 2000; 342: 749-755.
[10] Jang SJ, Yeo I, Feldman DN, Cheung JW, Minutello RM, Singh HS, Bergman G, Wong SC and Kim LK. Associations between hospital length of stay, 30-day readmission, and costs in ST-segment-elevation myocardial infarction after primary percutaneous coronary intervention: a nationwide readmissions database analysis. J Am Heart Assoc 2020; 9: e015503.
[11] Rathod KS, Comer K, Casey-Gillman O, Moore L, Mills G, Ferguson G, Antoniou S, Patel R, Fhadil S, Damani T, Wright P, Ozkor M, Das D, Guttmann OP, Baumbach A, Archbold RA, Wragg A, Jain AK, Choudry FA, Mathur A and Jones DA. Early hospital discharge following PCI for patients with STEMI. J Am Coll Cardiol 2021; 78: 2550-2560.
[12] Shah JA, Saghir T, Ahmed B, Ul Haq SA, Kumar R, Mengal MN, Zehra M, Raza SS, Karim M and Qamar N. Safety and feasibility of same day discharge strategy for primary percutaneous coronary intervention. Glob Heart 2021; 16: 46.
[13] Alzahrani N. The effect of hospitalization on patients' emotional and psychological well-being among adult patients: an integrative review. Appl Nurs Res 2021; 61: 151488.
[14] Laurencet ME, Girardin F, Rigamonti F, Bevand A, Meyer P, Carballo D, Roffi M, Noble S, Mach F and Gencer B. Early discharge in low-risk patients hospitalized for acute coronary syndromes: feasibility, safety and reasons for prolonged length of stay. PLoS One 2016; 11: e0161493.
[15] Asad ZUA, Khan SU, Amritphale A, Shroff A, Lata K, Seto AH, Khan MS, Rao SV and Abu-Fadel M. Early vs late discharge in low-risk ST-elevation myocardial infarction patients treated with percutaneous coronary intervention: a systematic review and meta-analysis. Cardiovasc Revasc Med 2020; 21: 1360-1368.
[16] Newby LK, Hasselblad V, Armstrong PW, Van de Werf F, Mark DB, White HD, Topol EJ and Califf RM. Time-based risk assessment after myocardial infarction. Implications for timing of discharge and applications to medical decision-making. Eur Heart J 2003; 24: 182-189.
[17] Howard J, Jones D, Gallagher S, Rathod K, Jain A, Mohiddin S, Knight C, Mathur A, Smith E and Wragg A. 048 is it safe to discharge patients 24 h after uncomplicated successful primary percutaneous coronary intervention? Heart 2012; 98 Suppl 1: A29-A30.
[18] Yndigegn T, Gilje P, Dankiewicz J, Mokhtari A, Isma N, Holmqvist J, Schiopu A, Ravn-Fischer A, Hofmann R, Szummer K, Jernberg T, James S, Gale CP, Frobert O and Mohammad MA. Safety of early hospital discharge following admission with ST-elevation myocardial infarction treated with percutaneous coronary intervention: a nationwide cohort study. EuroIntervention 2022; 17: 1091-1099.
[19] Monegro A, Muppidi V and Regunath H. Hospital Acquired Infections. 2021. [Online] Available at: https://www.ncbi.nlm.nih.gov/books/NBK441857/[Accessed 5 February 2022].
[20] Piccaro de Oliveira P, Gonzales V, Lopes RD, Schmidt MM, Garofallo S, Santos RP, Carrion L, Gottschall C and Quadros AS. Serious infections among unselected patients with ST-elevation myocardial infarction treated with contemporary primary percutaneous coronary intervention. Am Heart J 2016; 181: 52-59.
[21] Santos M, Oliveira M, Vieira S, Magalhaes R, Costa R, Brochado B, Santos R, Silveira J, Torres S and Luz A. Predictors and mid-term outcomes of nosocomial infection in ST-elevation myocardial infarction patients treated by primary angioplasty. Kardiol Pol 2021; 79: 988-994.
[22] Leistner DM, Munch C, Steiner J, Lauten A, Landmesser U and Stahli BE. Effect on outcomes: infections complicating percutaneous coronary interventions in patients ≥80 years of age. Am J Cardiol 2019; 123: 1806-1811.
[23] Gong W, Li A, Ai H, Shi H, Wang X and Nie S. Safety of early discharge after primary angioplasty in low-risk patients with ST-segment elevation myocardial infarction: a meta-analysis of randomised controlled trials. Eur J Prev Cardiol 2018; 25: 807-815.
[24] Jones DA, Rathod KS, Mathur A and Archbold RA. Discharge after primary percutaneous coronary intervention: the earlier the better? Eur Heart J Qual Care Clin Outcomes 2022; 8: 229-231.
[25] Marbach JA, Alhassani S, Chong AY, MacPhee E and Le May M. A novel protocol for very early hospital discharge after STEMI. Can J Cardiol 2020; 36: 1826-1829.

[26] Jirmár R, Widimsky P, Capek J, Hlinomaz O and Groch L. Next day discharge after successful primary angioplasty for acute ST elevation myocardial infarction. An open randomized study "Prague-5". Int Heart J 2008; 49: 653-659.
[27] Garratt KN. ST-segment-elevation myocardial infarction care in America: celebration and anxiety. J Am Heart Assoc 2020; 9: e016832.
[28] Halkin A, Singh M, Nikolsky E, Grines CL, Tcheng JE, Garcia E, Cox DA, Turco M, Stuckey TD, Na Y, Lansky AJ, Gersh BJ, O'Neill WW, Mehran R and Stone GW. Prediction of mortality after primary percutaneous coronary intervention for acute myocardial infarction: the CADILLAC risk score. J Am Coll Cardiol 2005; 45: 1397-1405.
[29] Gharacholou SM, Lopes RD, Alexander KP, Mehta RH, Stebbins AL, Pieper KS, James SK, Armstrong PW and Granger CB. Age and outcomes in ST-segment elevation myocardial infarction treated with primary percutaneous coronary intervention: findings from the APEX-AMI trial. Arch Intern Med 2011; 171: 559-567.
[30] Toleva O, Ibrahim Q, Brass N, Sookram S and Welsh R. Treatment choices in elderly patients with ST: elevation myocardial infarction - insights from the Vital Heart Response registry. Open Heart 2015; 2: e000235.
[31] Vavalle JP, van Diepen S, Clare RM, Hochman JS, Weaver WD, Mehta RH, Pieper KS, Patel MR, Patel UD, Armstrong PW, Granger CB and Lopes RD. Renal failure in patients with ST-segment elevation acute myocardial infarction treated with primary percutaneous coronary intervention: predictors, clinical and angiographic features & outcomes. Am Heart J 2016; 173: 57-66.
[32] Szummer K, Lundman P, Jacobson SH, Schon S, Lindback J, Stenestrand U, Wallentin L and Jernberg T; SWEDEHEART. Relation between renal function, presentation, use of therapies and in-hospital complications in acute coronary syndrome: data from the SWEDEHEART register. J Intern Med 2010; 268: 40-49.
[33] Addala S, Grines CL, Dixon SR, Stone GW, Boura JA, Ochoa AB, Pellizzon G, O'Neill WW and Kahn JK. Predicting mortality in patients with ST-elevation myocardial infarction treated with primary percutaneous coronary intervention (PAMI risk score). Am J Cardiol 2004; 93: 629-632.
[34] Hashmi KA, Adnan F, Ahmed O, Yaqeen SR, Ali J, Irfan M, Edhi MM and Hashmi AA. Risk assessment of patients after ST-segment elevation myocardial infarction by killip classification: an institutional experience. Cureus 2020; 12: e12209.
[35] Khaled S, Jaha N and Shalaby G. Clinical characteristics and short-term outcomes of patients presenting with acute myocardial infarction having multi-vessel disease - a single middle-eastern tertiary-care center experience. Indian Heart J 2022; 74: 28-33.
[36] Elakabawi K, Huang X, Shah SA, Ullah H, Mintz GS, Yuan Z and Guo N. Predictors of suboptimal coronary blood flow after primary angioplasty and its implications on short-term outcomes in patients with acute anterior STEMI. BMC Cardiovasc Disord 2020; 20: 391.
[37] Sevransky J. Clinical assessment of hemodynamically unstable patients. Curr Opin Crit Care 2009; 15: 234-238.
[38] Solhpour A, Chang KW, Arain SA, Balan P, Loghin C, McCarthy JJ, Vernon Anderson H and Smalling RW. Ischemic time is a better predictor than door-to-balloon time for mortality and infarct size in ST-elevation myocardial infarction. Catheter Cardiovasc Interv 2016; 87: 1194-1200.
[39] Alsamara M, Degheim G, Gholkar G, Hiner E and Zughaib M. Is symptom to balloon time a better predictor of outcomes in acute ST-segment elevation myocardial infarction than door to balloon time? Am J Cardiovasc Dis 2018; 8: 43-47.
[40] Shah P, Patel K, Vasudev R, Patel H, Thakkar S, Adalja D and Doshi R. Gender differences in the revascularization rates and in-hospital outcomes in hospitalizations with ST segment elevation myocardial infarction. Ir J Med Sci 2020; 189: 873-884.
[41] Chen S, David SW, Khan ZA, Metzger DC, Wasserman HS, Lotfi AS, Hanson ID, Dixon SR, LaLonde TA, Genereux P, Ozan MO, Maehara A and Stone GW. One-year outcomes of supersaturated oxygen therapy in acute anterior myocardial infarction: the IC-HOT study. Catheter Cardiovasc Interv 2021; 97: 1120-1126.