Can we improve length of hospitalization in ST elevation myocardial infarction patients treated with primary percutaneous coronary intervention?

Mark A Kotowycz MD MBA FRCPC^{1,2}, Renu Pal Syal¹, Rizwan Afzal MSc¹, Madhu K Natarajan MD MSc FRCPC FACC^{1,3}

MA Kotowycz, R Pal Syal, R Afzal, MK Natarajan. Can we improve length of hospitalization in ST elevation myocardial infarction patients treated with primary percutaneous coronary intervention? Can J Cardiol 2009;25(10):585-588.

BACKGROUND: Patients with ST elevation myocardial infarction have traditionally been hospitalized for five to seven days to monitor for serious complications such as heart failure, arrhythmias, reinfarction and death. The Zwolle primary percutaneous coronary intervention (PCI) index is an externally validated risk score that has been used to identify low-risk primary PCI patients who can safely be discharged from the hospital within 48 h to 72 h. **METHODS:** The Zwolle score was retrospectively applied to all ST elevation myocardial infarction patients treated with primary PCI between April 2004 and February 2006 at a large Canadian teaching hospital. The goal was to characterize length of stay (LOS) in low-risk patients and to identify variables that correlate with patients who were hospitalized longer than expected.

RESULTS: Data were collected on 255 patients. The mean LOS was 7.2 ± 7.7 days (median 5.0 days [interquartile range 3.5 days]). A total of 179 patients (70%) had a Zwolle score of 3 or lower, identifying them as low risk. There was one death in the low-risk group (0.6% 30-day mortality) and 15 deaths in the higher-risk group (19.7% 30-day mortality), validating the Zwolle score in the population. A contraindication to early discharge was identified in 34 of the low-risk patients. Among the 144 remaining low-risk patients, the mean LOS was 5.1 ± 3.3 days (median 4.0 days [interquartile range 3.0 days]). Only 8% were discharged within 48 h and only 28% within 72 h. It was determined that fewer patients were discharged on weekends and Wednesdays (when medical residents were away for teaching) than on other weekdays. LOS was longer among patients who were discharged on warfarin (7.6 days versus 4.6 days, $P=0.006$), and among patients who were transferred back to their presenting hospital rather than being discharged directly from the hospital where PCI was performed (5.6 days versus 4.0 days, $P<0.001$).

CONCLUSIONS: Seventy-two per cent of low-risk primary PCI patients were hospitalized longer than 72 h. The following three factors were identified as correlating with prolonged LOS in this population: fewer discharges on days when there was less resident staffing; the use of warfarin at discharge; and transfer of patients back to their presenting hospital rather than discharging them directly from the PCI-performing hospital. A programmed approach to the identification and early discharge of low-risk patients could have significant cost savings and should be investigated prospectively.

Key Words: Health care delivery; Length of stay; Primary PCI; STEMI

Patients with acute ST elevation myocardial infarction (STEMI) have traditionally been hospitalized for at least five to seven days to monitor for serious complications such as heart failure, arrhythmias, reinfarction and death. Although some of these complications do not

Peut-on réduire la durée d'hospitalisation des patients ayant eu un infarctus du myocarde avec élévation du segment ST traités au moyen d'une intervention coronaire percutanée primaire ?

HISTORIQUE : Les patients ayant un infarctus du myocarde avec élévation du segment ST sont généralement hospitalisés de cinq à sept jours pour surveiller l'apparition de graves complications comme l'insuffisance cardiaque, l'arythmie, un nouvel infarctus et la mort. L'indice d'intervention coronaire percutanée (ICP) primaire de Zwolle est un indice de risque externe validé, utilisé pour repérer les patients à faible risque ayant subi une IPC primaire et pouvant obtenir leur congé de l'hôpital dans les 48 à 72 heures.

MÉTHODOLOGIE : On a appliqué de manière prospective l'indice de Zwolle à tous les patients ayant subi un infarctus du myocarde avec élévation du segment ST chez qui on avait procédé à une IPC primaire entre avril 2004 et février 2006 dans un grand hôpital universitaire canadien. On visait ainsi à caractériser la durée d'hospitalisation (DH) chez les patients à faible risque et à déterminer les variables liées aux patients hospitalisés plus longtemps que prévu.

RÉSULTATS : On a colligé des données auprès de 255 patients. La DH moyenne était de $7,2 \pm 7,7$ jours (médiane de 5,0 jours [plage interquartile de 3,5 jours]). Au total, 179 patients (70 %) avaient un indice de Zwolle de 3 ou moins, les catégorisant à faible risque. On a constaté un décès dans le groupe à faible risque (0,6 % de mortalité au bout de 30 jours) et 15 décès dans le groupe à plus haut risque (19,7 % de mortalité au bout de 30 jours), validant l'indice de Zwolle dans la population. On a repéré une contre-indication à un congé précoce chez 34 patients à faible risque. Parmi les 144 autres patients à faible risque, la DH moyenne était de $5,1 \pm 3,3$ jours (médiane de 4,0 jours [plage interquartile de 3,0 jours]). Seulement 8 % ont reçu leur congé dans les 48 heures et seulement 28 %, dans les 72 heures. On a déterminé que moins de patients obtenaient leur congé la fin de semaine et le mercredi (lorsque les résidents en médecine étaient absents pour enseigner) que les autres jours. La DH était plus longue chez les patients qui obtenaient leur congé avec un traitement à la warfarine (7,6 jours par rapport à 4,6, $P=0,006$) et chez ceux qui étaient retransférés à l'hôpital où ils s'étaient présentés que chez ceux qui obtenaient leur congé directement de l'hôpital où avait eu lieu l'ICP (5,6 par rapport à 4,0, $P<0,001$).

CONCLUSIONS : Soixante-douze pour cent des patients à faible risque ayant subi une ICP primaire étaient hospitalisés plus de 72 heures. On a déterminé que les trois facteurs suivants étaient liés à une DH prolongée au sein de cette population : moins de congés les jours où il y avait moins de résidents au sein du personnel, utilisation de warfarine au congé et transfert des patients à l'hôpital où ils s'étaient présentés plutôt qu'obtention d'un congé de l'hôpital ayant procédé à l'ICP. Une démarche programmée en vue de repérer les patients à faible risque et de leur donner un congé précoce pourrait assurer des économies importantes et devrait faire l'objet d'une recherche prospective.

occur immediately and necessitate an extended period of in-hospital monitoring, it has long been recognized that there is a subset of STEMI patients who are unlikely to develop complications and do not require extensive observation. Twenty years ago, Topol et al (1) demonstrated

¹Population Health Research Institute, Hamilton Health Sciences, Hamilton, Ontario; ²Division of Cardiology, McGill University, Montreal, Quebec;

³Division of Cardiology, McMaster University, Hamilton, Ontario

Correspondence: Dr Madhu Natarajan, Hamilton Health Sciences – General Site, McMaster Clinics, Room 263, 237 Barton Street East, Hamilton, Ontario L8L 2X2. Telephone 905-527-6241, fax 905-527-2337, e-mail natarajm@ccc.mcmaster.ca

Received for publication April 28, 2008. Accepted August 17, 2008

TABLE 1
The Zwolle primary percutaneous coronary intervention index

Category	Points
Killip class	
1	0
2	4
3-4	9
Thrombolysis In Myocardial Infarction (TIMI) flow grade following angioplasty	
3	0
2	1
0-1	2
Age, years	
<60	0
≥60	2
Three-vessel disease	
No	0
Yes	1
Anterior infarction	
No	0
Yes	1
Ischemic time	
≤4 h	0
>4 h	1
Highest possible score	16

Patients with a total score of 3 or lower are considered to be low risk and can safely be discharged within 48 h to 72 h. Data from reference 4

that carefully selected patients with uncomplicated infarctions could safely be discharged at 72 h with substantial cost savings.

The increasing use of primary percutaneous coronary intervention (PCI) as the treatment of choice for STEMI allows for early identification of coronary anatomy, left ventricular function and immediate revascularization. In recent years, a significant amount of effort has been made to optimize the upfront management of STEMI patients because it has become clear that time to revascularization has a direct impact on patient survival (2). There has been a push to regionalize STEMI care to hospitals that offer primary PCI 24 h per day, seven days per week, to implement prehospital electrocardiogram programs, and to bypass emergency departments (EDs) altogether, all in an effort to reduce door-to-balloon times (3). As the number of STEMI patients receiving early reperfusion continues to increase, the ability to identify and discharge low-risk patients has become more relevant than ever before. Information on length of stay (LOS) and hospital discharge practices could have important implications for health care costs, resource use and patient satisfaction, but these types of data are currently quite limited.

The Zwolle primary PCI index (4) is an externally validated risk scoring system that can be used to identify a significant proportion (approximately 70%) of primary PCI patients who have a 30-day mortality of 0.5% and a risk of malignant ventricular arrhythmias after 48 h of only 0.2%. The authors of the Zwolle paper argue that in the absence of contraindications, these low-risk patients (Zwolle score of 3 or lower; Table 1) can safely be discharged from the hospital after 48 h to 72 h. One goal of the present study was to retrospectively calculate a Zwolle score for all primary PCI patients in a prospectively collected cohort of STEMI patients and to characterize LOS in those identified as low risk. The second goal was to identify any additional variables that correlated with the low-risk patients who were hospitalized for longer than expected (ie, longer than 72 h).

METHODS

Primary PCI patients were identified from a prospectively collected database of all STEMI patients treated at Hamilton Health Sciences

Figure 1) Thirty-day mortality is positively correlated with the Zwolle score, validating the use of this score in the present population

(Hamilton, Ontario) between April 2004 and February 2006. This included patients who presented to the hospital's ED, as well as patients who presented to other EDs in the region but were urgently transferred to Hamilton Health Sciences for primary PCI. Some of these transferred patients were repatriated back to their base hospital following primary PCI as part of a bed allocation strategy. Patients initially identified as primary PCI candidates who no longer required intervention by the time of angiography (ie, those with spontaneous reperfusion or coronary spasm) were excluded from the analysis. Patients undergoing rescue angioplasty were also excluded. Although the majority of patients in the study presented within 12 h of symptom onset, those who presented later were not excluded. The small minority of patients who required multivessel PCI during the index procedure were also not excluded.

A Zwolle score was calculated for each patient, as outlined in Table 1. LOS was defined as the time (in days) from first balloon inflation to the date and time of discharge. In cases in which a discharge time was not recorded in the chart, a conservative value of midnight at the end of the discharge day was used. Data were analyzed using Microsoft Excel version 11.0 (Microsoft Office 2003; Microsoft Corporation, USA).

RESULTS

Data were extracted from 255 charts. Thirty-day follow-up data were available for 253 of these patients (99.2%). The mean LOS was 7.2 ± 7.7 days. The median LOS was 5.0 days, with an interquartile range of 3.5 days. The mean Zwolle score was 3.2 (median 3.0).

It was determined that 179 patients (70%) had a Zwolle score of 3 or lower, identifying them as low risk. This was very similar to the incidence of low-risk patients observed in the Zwolle derivation cohort (73%) (4). There was one death in the low-risk group (30-day mortality of 0.6%). The death occurred in the hospital, 24 h after PCI. There were 15 deaths in the higher-risk group (30-day mortality of 19.7%). The overall 30-day mortality was 6.3% and mortality rates showed a positive correlation with increasing Zwolle score (Figure 1), validating the Zwolle score in the present population (*c* statistic 0.72).

In the Zwolle paper, the authors were able to identify a contraindication to early discharge in 17% of low-risk patients (Zwolle score of 3 or lower). These contraindications were significant anemia or bleeding, arrhythmias, heart failure, need for cardiac surgery, use of intra-aortic balloon pump, fever, pericardial effusion, reocclusion and renal insufficiency. In the remaining 83% of low-risk patients, the authors could not find any contraindication to discharge at 48 h to 72 h. A similar methodology was applied to the present population; it was determined that 34 of the low-risk patients (19%) had an identifiable contraindication to early discharge (Table 2). In the remaining 144 low-risk patients (81%) with no obvious contraindication to early discharge, the mean LOS was 5.1 ± 3.3 days (median

TABLE 2
Contraindications to early discharge identified in 34 of the low-risk patients

Contraindication to early discharge	Patients, n
Recurrent myocardial infarction	1
Staged percutaneous coronary intervention or coronary artery bypass graft surgery	3
Stroke	1
Major bleeding	9
Ventilation	9
Intra-aortic balloon pump	6
Pacemaker/arrhythmia	12
Mechanical complication	2
Total contraindications	43

The total is greater than 34 patients because some patients had multiple contraindications

4.0 days [interquartile range 3.0 days]). Only 8% of those patients were discharged within 48 h and only 28% within 72 h.

Because documented reasons for keeping the majority of low-risk patients in the hospital beyond 72 h could not be found, an attempt was made to identify additional variables that might be contributing to a prolonged LOS. When low-risk discharges were plotted by day of the week, it was found that the number of discharges on Wednesdays, Saturdays and Sundays was approximately one-half of the number of discharges seen on other days of the week (Figure 2). The low number of discharges on Wednesdays was unexpected and may have been related to the fact that at Hamilton Health Sciences, most residents have protected teaching time every Wednesday afternoon and are relieved of clinical duties. Although discharge decisions are often made during morning rounds, it is possible that these decisions may not be carried out on the same day if residents have other commitments. It was also found that LOS was longer for patients who were discharged on warfarin (7.6 days versus 4.6 days, $P=0.006$) and for patients who were repatriated back to their presenting hospital and then discharged rather than being discharged directly from the hospital where PCI was performed (5.6 days versus 4.0 days, $P<0.001$).

DISCUSSION

In patients with acute myocardial infarction, there is an acute increase in death and complications superimposed on a low background rate of events that is unaffected by LOS (5). Deaths that occur after 72 h can largely be attributed to complications that occurred early or to the background rate of events. Numerous bedside tools have been developed to stratify patients with STEMI to identify a low-risk group of patients who are unlikely to experience complications above the background rate and who can be discharged from the hospital after a brief period of observation. The Zwolle primary PCI index (4) incorporates procedural variables (eg, Thrombolysis In Myocardial Infarction [TIMI] flow following angioplasty) that were not captured by earlier scoring systems (eg, Global Registry of Acute Coronary Events [GRACE] [6], Primary Angioplasty in Myocardial Infarction [PAMI] [7] and TIMI-STEMI [8]) and clearly identifies a majority of patients who can be discharged early. Although a more comprehensive score in the setting of primary PCI has since been reported (ie, the Controlled Abciximab and Device Investigation to Lower Late Angioplasty Complications [CADILLAC] [9] score), we found that the Zwolle score was practical as a clinical bedside tool, with the ability to discriminate between high- and low-risk patients. In addition, the Zwolle score was externally validated in the CADILLAC publication.

We retrospectively applied the Zwolle score to a group of primary PCI patients at our institution and found that 72% of low-risk patients with no identifiable contraindication to early discharge were kept in the hospital longer than predicted. The reasons for this are not entirely

Figure 2) The number of low-risk primary percutaneous coronary intervention patients varied by day of the week. At Hamilton Health Sciences (Hamilton, Ontario), medical residents are relieved of clinical duties on Wednesday afternoons to make room for protected teaching time

clear, although we did identify three system factors that may contribute to increased LOS. First, we found that on days with decreased physician staffing (ie, Wednesdays, Saturdays and Sundays), the number of discharges was roughly one-half of what it was on other days. The phenomenon of decreased weekend discharges has previously been well described (10) but we believe that our study is the first to highlight the impact of resident staffing during the week on discharge practices in teaching hospitals. Second, we found that patients who are discharged on warfarin have a markedly prolonged LOS, although the absolute number of low-risk patients on warfarin is quite small (less than 6% in our study). Third, we found that patients who were transferred back to their presenting hospital for further management and discharge had an LOS approximately 1.5 days longer than patients discharged directly from the hospital in which primary PCI was performed. It may, in fact, be preferable to discharge low-risk primary PCI patients from the PCI-performing hospital. Although this would increase bed use at the PCI-performing hospital, it should decrease the overall demand for beds in the region. The implementation of such a strategy would require that staff at the PCI-performing hospital have access to general physicians, cardiac rehabilitation and other community support services in the regions served by the referring hospitals.

Our study has several important limitations. First, it describes a single-centre experience with only 255 patients and our results may not reflect practice patterns in other centres, particularly in centres outside of Canada. However, it is interesting to note that another recent Canadian study (11) reached a conclusion that was similar to ours – the authors found that only 28% of low-risk primary PCI patients identified using the CADILLAC score were discharged from the hospital before the target date of discharge. Another important limitation is that our study was retrospective. We performed an unadjusted exploratory analysis and identified several factors that correlate with a prolonged LOS. However, we have not demonstrated causality and there are likely other important factors that prolong LOS that cannot be determined from a chart review. Finally, although risk scores such as Zwolle and CADILLAC identify low-risk patients who could theoretically be discharged from the hospital early, very few data support the feasibility or cost effectiveness of such a strategy. Again, the retrospective nature of our study did not allow us to address this important issue.

Newby et al (12) found that hospitalizing patients with uncomplicated infarctions for more than three days is not cost effective. We believe that a programmed approach to the identification and early discharge of low-risk patients could result in significant cost savings and should be investigated prospectively. The Safety And Feasibility of Early Discharge – a Prospective And Randomized Trial of Low-Risk Primary PCI Patients (SAFE-DEPART) (clinicaltrials.gov #NCT00474214) is a prospective, randomized pilot trial designed to address the implementation of such a strategy. Low-risk primary PCI patients are being randomly assigned to an intervention arm (early hospital discharge

facilitated by early outpatient follow-up with a nurse) or to standard of care (no recommended date of discharge and no outpatient follow-up with a nurse). After six weeks, data are collected to assess whether the intervention is feasible, safe and cost effective, and whether it has an impact on the quality of life of patients.

SUMMARY

We found that 72% of low-risk primary PCI patients are kept in the hospital longer than 72 h. In many of these patients, the reason for

the prolonged hospitalization is not clear. We identified the following three potentially modifiable factors that correlate with prolonged LOS in the present population: fewer discharges on days with less resident staffing; the use of warfarin at discharge; and transfer of patients back to their presenting hospital rather than discharging directly from the PCI-performing hospital. Finally, prospective trials, such as SAFE-DEPART, may provide additional insights into the safety and feasibility of an early discharge strategy in this patient population.

REFERENCES

1. Topol EJ, Burek K, O'Neill WW, et al. A randomized controlled trial of hospital discharge three days after myocardial infarction in the era of reperfusion. *N Engl J Med* 1988;318:1083-8.
2. McNamara RL, Wang Y, Herrin J, et al. Effect of door-to-balloon time on mortality in patients with ST-segment elevation myocardial infarction. *J Am Coll Cardiol* 2006;47:2180-6.
3. Nallamothu BK, Bradley EH, Krumholz HM. Time to treatment in primary percutaneous coronary intervention. *N Engl J Med* 2007;357:1631-8.
4. De Luca G, Suryapranata H, van't Hof AW, et al. Prognostic assessment of patients with acute myocardial infarction treated with primary angioplasty: Implications for early discharge. *Circulation* 2004;109:2737-43.
5. Newby LK, Hasselblad V, Armstrong PW, et al. Time-based risk assessment after myocardial infarction. Implications for timing of discharge and applications to medical decision-making. *Eur Heart J* 2003;24:182-9.
6. Granger CB, Goldberg RJ, Dabbous O, et al. Predictors of hospital mortality in the global registry of acute coronary events. *Arch Int Med* 2003;163:2345-53.
7. Addala S, Grines CL, Dixon SR, et al. Predicting mortality in patients with ST-elevation myocardial infarction treated with primary percutaneous coronary intervention (PAMI risk score). *Am J Cardiol* 2004;93:629-32.
8. Morrow DA, Antman EM, Charlesworth A, et al. TIMI risk score for ST-elevation myocardial infarction: A convenient, bedside, clinical score for risk assessment at presentation. *Circulation* 2000;102:2031-7.
9. Halkin A, Singh M, Nikolsky E, et al. Prediction of mortality after primary percutaneous coronary intervention for acute myocardial infarction: The CADILLAC risk score. *J Am Coll Cardiol* 2005;45:1397-405.
10. Varnava AM, Sedgwick JEC, Deaner A, et al. Restricted weekend service inappropriately delays discharge after acute myocardial infarction. *Heart* 2002;87:216-9.
11. McMeekin J, Traboulsi M, Stolee B, et al. Next steps in STEMI care: Use of the CADILLAC risk score to target discharge from hospital. *Can J Cardiol* 2007;23(Suppl C):121C.
12. Newby LK, Eisenstein EL, Califf RM, et al. Cost-effectiveness of early discharge after uncomplicated acute myocardial infarction. *N Engl J Med* 2000;342:749-55.