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STEMI mortality in community hospitals versus PCI-capable hospitals: results from a nationwide STEMI network programme

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Abstract

Aims: Reports examining local ST elevation myocardial infarction (STEMI) networks focused mainly on percutaneous coronary intervention (PCI)-related time issues and outcomes. To validate the concept of STEMI networks in a real-world context, more data are needed on management and outcome of an unselected community based STEMI population.

Methods and results: The current study evaluated reperfusion strategies and in-hospital mortality in 8500 unselected STEMI patients admitted to 47 community hospitals (n=3053) and 25 PCI-capable hospitals (n=5447) in the context of a nationwide STEMI network programme that started in 2007 in Belgium. The distance between the hub and spoke hospitals ranged from 2.2 to 47 km (median 15 km). A propensity score was used to adjust for differences in baseline characteristics. Reperfusion strategy was significantly different with a predominant use of primary PCI (pPCI) in PCI-capable hospitals (93%), compared to a mixed use of pPCI (71%) and thrombolysis (20%) in community hospitals. A door-to-balloon time <120 min was achieved in 83% of community hospitals and in 91% of PCI-capable hospitals (p<0.0001). In-hospital mortality was 7.0% in community hospitals versus 6.7% in PCI-capable hospitals with an adjusted odds ratio of 1.1 (95% confidence interval: 0.8–1.4). Between the periods 2007–2008 and 2009–2010, the pPCI rate in community hospitals increased from 60% to 80%, whereas the proportion of conservatively managed patients decreased from 11.1% to 7.9%.

Conclusion: In a STEMI network with >70% use of pPCI, in-hospital mortality was comparable between community hospitals and PCI-capable hospitals. Participation in the STEMI network programme was associated with an increased adherence to reperfusion guidelines over time.

Keywords

ST elevation myocardial infarction, primary PCI, networks

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Introduction

The current guidelines for the management of ST-segment elevation myocardial infarction (STEMI) recommend primary percutaneous coronary intervention (pPCI) as the preferred treatment strategy if it can be conducted in a timely fashion by an experienced catheterisation team.[1,2] However, because of logistical restraints, PCI can only be offered in less than 50% of European and US hospitals.[3,4] This limitation has placed policy makers under pressure to develop healthcare systems that offer equally good medical support to all inhabitants of a region/nation. This has shifted the focus towards extension of PCI benefits to patients who present to community hospitals with no interventional capabilities. Several randomised trials have demonstrated that transferring STEMI patients to PCI-capable hospitals for primary PCI is safe and leads to better outcomes than administration of thrombolytic therapy at community hospitals.[5] This has formed the basis of the development of STEMI networks with prearranged rapid transfer protocols between community hospitals and PCI centres.[6] Nonetheless, the randomised trial populations may not be representative of the majority of patients seen in clinical practice, and transfer delays are frequently longer outside the context of a study protocol. Although early experiences with local STEMI networks were encouraging, those reports mainly focused on PCI-related time issues and transferred patient outcome, whereas outcome data of non-transferred patients in community hospitals were lacking.[7–10] To validate the concept of STEMI networks in a real-world context, more data are needed on management and outcome of an unselected community-based STEMI population.

Accordingly, the current study evaluates reperfusion strategy and in-hospital mortality in community hospitals and PCI-capable hospitals in the context of a real-world nationwide STEMI network programme that was started in Belgium in 2007.

Methods

STEMI network programme and study population

At the beginning of 2007, a nationwide quality-improvement project for STEMI was launched and supported by the Belgian government. At the start of the STEMI network programme, Belgium already had a high density of PCI-capable hospitals (27 PCI centres for 10 million inhabitants) that provided round-the-clock service for pPCI. Regional meetings were organised to promote the concept of a STEMI network in concordance with the European Society of Cardiology (ESC) guidelines.[11] An algorithm derived from the 2005 European guidelines recommended bringing the patient to a PCI-capable hospital as soon as possible, in conjunction with recommendations to initiate thrombolytic therapy if pPCI could not be offered in a timely fashion, particularly in the case of patients with a symptom duration of <3 h and an anticipated transfer time >60 min.[12] The use of pre-hospital electrocardiograms has allowed a better diagnosis, triage and direct transfer to designated PCI-capable hospitals.[9] In addition, a national STEMI database was set up containing the demographics, practice patterns and health outcomes of unselected patients with STEMI. Benchmarking reports were provided online to all participating centres. A total of 25 of the 27 PCI-capable hospitals and 47 of the 83 community hospitals participated actively in this STEMI database. At the time of the analysis, the registry included a total of 8500 patients with ST elevation or presumed new left bundle branch block who were admitted to one of the 72 hospitals between 1 June 2007 and 31 December 2010. All PCI-capable hospitals were appropriately trained and according to the American Heart Association (AHA) recommendations for primary PCI, the majority (n=22) were highly experienced (>36 annual pPCI rate).[13] All 47 community hospitals provided standard medical care to STEMI patients in intensive cardiac care units. Figure 1 shows the regional distribution of community hospitals and PCI-capable hospitals superimposed on a chart of the population density of the country. The majority of PCI-capable hospitals are located in urban areas. The distance between the community hospitals and the PCI-capable hospitals ranged from 2.2 to 47 km (median 15 km). Low-volume hospitals – defined as hospitals with an enrolment of <100 STEMI patients during the study period – included 3 PCI-capable hospitals (12%) and 39 community hospitals (83%).

The database is managed by an independent electronic data capture provider (Lambda-plus, Gembloux, Belgium) that also manages internal data quality. Online benchmarking reports were provided to all participating hospitals. The data validity was checked in 10% of the patient files by an external auditing commission. The database was registered with clinicaltrials.gov (NCT00727623). The database was approved by the Belgian Data Protection Agency. Informed consent was obtained from all patients or from their legal representatives.

Risk assessment and treatment strategy

A number of baseline characteristics for each patient were included allowing stratification of the patients according to a previously validated Thrombolysis in Myocardial Infarction (TIMI) risk score for STEMI patients[14]: age, haemodynamic status on admission, history of atherovascular disease, history of hypertension or diabetes. The following types of reperfusion strategy were defined: thrombolysis, pPCI and conservative treatment (without reperfusion therapy). In addition, for thrombolysis patients and for conservatively managed patients, subsequent invasive evaluation either during the acute phase following failed thrombolysis or electively during index hospitalisation was recorded. Patient who underwent rescue PCI because of failed thrombolysis remained classified as

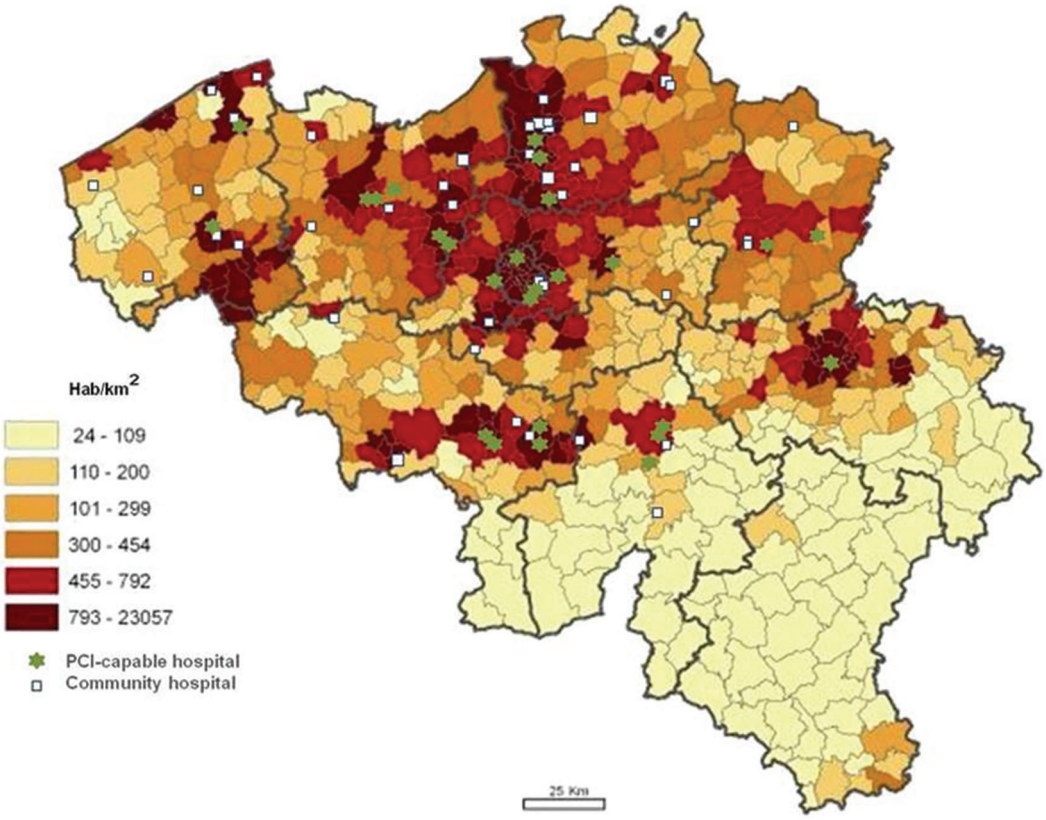

Figure 1. Population density chart of Belgium with the regional distribution of community hospitals and PCI-capable hospitals that participated in the study.

thrombolysis patients. All treatment decisions were made at the discretion of the treating physicians. Total ischaemic time was defined as the time from symptom onset to the start of thrombolysis or the time from symptom onset to the first balloon inflation and was subdivided into time periods of <2 h, 2–4h, 4–8 h, 8–12 h and >12 h. The periods related to the initiation of reperfusion were recorded according to the time delays as follows: door-to-needle time (DTNT) was defined as time from diagnosis of STEMI until initiation of thrombolysis and was available for 671 patients (87.6% of the thrombolysis patients); door-to-balloon time (DTBT) was defined as time from STEMI diagnosis until first balloon inflation and was available for 7012 patients (96.8% of the PCI patients). The time periods were subdivided into <30 min, ≥30 min and <60 min, ≥60 min and <90 min, ≥90 min and <120 min and ≥120 min.

The primary endpoint was in-hospital death from all causes as late as 30 days after admission. Vital status was assessed in the final hospital before home discharge.

Statistical analysis

Continuous variables are presented as the mean values with corresponding standard deviation (SD). Comparisons between groups were made with an unpaired t-test. The differences between proportions were assessed by chi-squared analysis. Independent determinants of in-hospital death were determined by means of multiple logistic regression analysis and reported as odds ratios (ORs) and 95% confidence intervals (CIs). The following factors were included in this analysis: age, gender, weight, history of CAD or PAD, arterial hypertension, diabetes mellitus, Killip class, blood pressure and heart rate on admission, infarct location, cardiac arrest with rescuscitation, total ischaemic time and hospital volume as defined by the number of enrolled STEMI patients. A propensity score was used to adjust for differences in baseline characteristics between community hospital-admitted patients and PCI-capable hospital-admitted patients.[15] Comparison between the periods 2007–2008 and 2009–2010 was achieved by adding an interaction term between admission centre and period to the logistic regression model. For all analyses, a value of $p<0.05$ was considered statistically significant. All statistical analyses were performed using SAS version 9.1 (SAS Institute, Cary, NC, USA).

Results

Baseline characteristics and treatment modalities

The total study population consisted of 8500 patients. Of the total population, 3053 patients (37%) were admitted to

Table 1. Baseline patient characteristics and treatment modalities.

Characteristics	Community hospital *N*=3053	PCI–capable hospital *N*=5447	*p*-value
Age (years)	63.7±13.5	62.6±13.1	0.0003
Men (%)	72.7	77	<0.0001
Weight<67 kg (%)	18.4	17.3	0.17
Previous CAD (%)	16.8	19.7	0.0007
Previous PAD (%)	8.8	10.3	0.03
Arterial hypertension (%)	42.2	45.2	0.01
Diabetes (%)	14.2	15.9	0.04
Killip Class>1 (%)	20.4	23.1	0.0001
Heart rate>100 bpm (%)	14.0	14.5	0.05
Blood pressure<100 mmHg (%)	21	15	0.0001
CPR (%)	8.8	11.8	<0.0001
Infarct location (%)			
Anterior or LBBB	45.2	44.3	0.67
Time from symptom onset to treatment:			
< 2 h (%)	23.9	24.1	
2–4 h (%)	39.5	43.6	<0.0001
4–8 h (%)	22.4	18.8	
8–12 h (%)	7.2	6.2	
>12 h (%)	6.9	7	
TIMI risk score	4.3±2.9	4.2±2.9	0.29
Treatment:			
Thrombolysis (%)	19.9	2.9	<0.0001
Primary PCI (%)	70.7	93.3	
Conservative (%)	9.4	3.7	
Door-to-needle time (%)			
<30 min	53.0	60.5	0.3
30–60 min	21.8	20.4	
>60 min	25.2	19.1	
Door-to-balloon time (%)			
<60 min	40.8	60.6	<0.0001
60–90 min	27.4	21.8	
90–120 min	14.5	8.6	
>120 min	17.3	9.0	

Values are represented as mean ± standard deviations or percentages. PCI, percutaneous coronary intervention; CAD, coronary artery disease; PAD, peripheral artery disease; LBBB, left bundle branch block; TIMI, thrombolysis in myocardial infarction.

a community hospital and 5447 (63%) to a PCI-capable hospital. The baseline characteristics of the two patient groups are shown in Table 1. Patients admitted to community hospitals were older, a higher percentage was female and had longer total ischaemic time delays, but had less concomitant pathology and were haemodynamically more stable than patients admitted to PCI-capable hospitals. The overall TIMI risk score was not significantly different between both study groups: 4.3 vs 4.2 (p=0.3). Treatment strategy was highly different between both study groups. Primary PCI was the predominant treatment strategy (93.3%) in PCI-capable centres, whereas in community hospitals, both transfer for pPCI (70.7%) and thrombolytic therapy (20%) were offered to patients. Fibrinolysis was given pre-hospital for 16.6% of the thrombolysis patients. Conservative therapy was offered more often to community hospitalised patients (9.4% vs 3.7%) and was mostly related to presentation that was too late (78%) or to severe comorbidity (14%). In community-hospitalised patients, the TIMI risk score of thrombolysis patients was lower than that of pPCI patients: 3.8 ± 2.7 vs 4.1 ± 2.9 (p=0.03). Door-to-needle time was comparable between community hospitals and PCI-capable hospitals. Door-to-balloon time was longer in community hospitals and was closely related to longer transfer times. A door-to-balloon time <120 min was obtained in 83% of community hospitals and in 91 % of PCI-capable hospitals (p<0.0001)

Many of the 867 (69%) thrombolysis and conservatively-managed patients underwent subsequent invasive evaluation either in the acute phase after failed thrombolysis (n=210) or electively during index hospitalisation (n= 657).

Table 2. Hospital mortality and adjusted odds ratios for different reperfusion modalities.

	Community hospital	PCI-capable hospital	Adjusted OR (95%CI)
Total population (%)	7	6.7	1.1 (0.8–1.4)
Thrombolysis (%)	5.2	11.4	0.49 (0.2–1.1)
Primary PCI (%)	6.1	5.9	1.1 (0.7–1.5)
Conservative (%)	17.1	21.2	0.7 (0.4–1.3)

CI, confidence interval; OR, odds ratio community hospital over PCI capable hospital; PCI, percutaneous coronary intervention.

Table 3. Predictors of in-hospital mortality.

Characteristics	OR (95% CI)
Age (years)	1.05 (1.04–1.06)
Killip class>1	5.3 (4.1–6.7)
CPR	5.0 (3.9–6.4)
Blood pressure <100 mmHg	2.6 (2.1–3.2)
Heart rate >100 bpm	1.4 (1.1–1.8)
Previous PAD	1.8 (1.4–2.4)
Female	1.4 (1.1–1.7)
Anterior infarct location,	1.3 (1.0–1.5)
Ischaemic time	
4–12 h vs <4 h	1.3 (1.0–1.7)
>12 h vs <4 h	2.0 (1.6–2.6)
Weight <67 kg	1.05 (0.8–1.4)
Previous CAD	1.1 (0.9–1.4)
Arterial hypertension	1.03 (0.8–1.3)
Diabetes	0.98 (0.7–1.3)
Volume <100	0.9 (0.7–1.3)
Community hospital	1.1 (0.8–1.4)

CAD, coronary artery disease; CI, confidence interval; PAD, peripheral artery disease; CPR, cardiopulmonary resuscitation; CAD, coronary artery disease; OR, odds ratio; PCI, percutaneous coronary intervention.

In-hospital mortality and its predictors

The in-hospital mortality of the total study population was 6.8% and occurred within a median of 2 days (25th and 75th percentiles: 0–7days) after admission.

In-hospital mortality was 7.0% in community-hospitalised patients versus 6.7% in patients admitted to PCI-capable hospitals (p=0.6). After correction for differences in baseline characteristics, the adjusted odds ratio was 1.1 (95% confidence interval: 0.8–1.4). The mortality rates of different reperfusion strategies are shown in Table 2. No significant differences were observed between the study groups although there was a clear trend to a higher mortality rate for thrombolysed patients admitted to PCI-capable centres. There was no difference in mortality in patients receiving reperfusion therapy within 2 hours after onset of pain (5.7% in community-hospitalised patients versus 6.3% in patients admitted to PCI-capable hospitals; p=0.6).

Table 4. Temporal changes in community hospitals.

	Period 2007–2008 N=1384	Period 2009–2010 N=1669	p-value
TIMI risk score	4.3 ± 2.9	4.2 ± 2.9	0.3
Thrombolysis (%)	28.7	12.6	0.0001
Primary PCI (%)	60.2	79.5	
conservative (%)	11.1	7.9	
Door-to-balloon time (%)			
<60 min	40.6	41.0	0.02
60–90 min	30.5	25.4	
90–120 min	13.9	14.9	
>120 min	14.9	18.7	
Mortality (%)	7.3	6.7	0.9[a]

Values are represented as mean ± standard deviations or percentages. PCI, percutaneous coronary intervention; TIMI, thrombolysis in myocardial infarction. [a]Adjusted odds ratio: 1.02 (95% CI: 0.7–1.4).

Table 5. Temporal changes in PCI-capable hospitals.

	Period 2007–2008 N=2670	Period 2009–2010 N=2777	p-value
TIMI risk score	4.3 ± 3.0	4.1 ± 2.8	0.002
Thrombolysis (%)	4.1	1.7	0.0001
Primary PCI (%)	92.0	94.9	
No reperfusion (%)	4.1	3.4	
Door-to-balloon time (%)			
<60 min	58.6	62.4	0.07
60–90 min	23.3	20.4	
90–120 min	8.8	8.4	
>120 min	9.0	8.7	
Mortality (%)	6.9	6.5	0.13[a]

Values are represented as mean ± standard deviations or percentages. PCI, percutaneous coronary intervention; TIMI, thrombolysis in myocardial infarction. [a]Adjusted odds ratio: 0.8 (95% CI: 0.6–1.06).

Table 3 summarises the independent predictors of in-hospital mortality. The most important independent risk factors for in-hospital death were older age, Killip class >1, low blood pressure, high heart rate, cardiac arrest, history of peripheral artery disease (PAD), long ischaemic time delay, female gender and an anterior infarction location. There were no significant differences between community hospitals versus PCI-capable centres. Also there were no differences between hospitals with a high-volume versus hospitals with a low volume of enrolled STEMI patients.

Temporal changes in management and outcome

Changes in reperfusion therapy and outcome are shown in Tables 4 and 5. Between the periods 2007–2008 and 2009–2010, there was a profound shift towards more primary PCI, particularly in the community hospitals. The primary PCI rate in community hospitals increased from 60% to 80% at the cost of less thrombolysis and less conservative

treatment ($p<0.0001$). In addition, over time there was a significant but modest improvement in the time delay related to primary PCI in both the community and PCI-capable hospitals. However, mortality rates were not significantly different between the two study periods.

Discussion

The present study demonstrated that in a STEMI network, in-hospital mortality of patients admitted to community hospitals is comparable to patients admitted to PCI-capable hospitals. In addition, participation in a STEMI network programme with online benchmarking reports was associated with an increased adherence to guidelines over time.

The concept of a STEMI network was introduced after the publication of several randomised clinical trials demonstrating that transferring STEMI patients to PCI-capable centres for primary PCI leads to better outcomes than on-site administration of fibrinolytic therapy.[5,6,16] However, some concerns emerged as to what extent this observed benefit could be translated into daily practice. Indeed, in those randomised trials, patients at high risk (for example, with cardiogenic shock) were excluded and the thrombolytic regime was suboptimal (no routine invasive evaluation post-thrombolysis and less use of potent adjunctive pharmacotherapy). The data of the present study, which also include high-risk patients, are reassuring since the presumed outcome gap between PCI-capable hospitals and community hospitals seems to be resolved by the implementation of the STEMI network. The high use of pPCI (>70%) is a prerequisite for obtaining these results, as was recommended by a recent task force.[17]

The findings of the present study may help policy makers identify the optimal number of PCI centres needed to provide high quality care to a region's inhabitants. Our data do not support a further increase in the number of PCI centres in urban regions in Belgium, as PCI centres with a reasonable PCI-related time delay are already widely available in these regions. This is in line with recent data that recommend that one PCI centre serves a total population of 0.3–0.8 million.[3] Increasing the number of PCI hospitals carries a risk for loss of experience, which has been associated with higher mortality rates.[18]

Our data may foster the debate on whether treatment of STEMI patients should be restricted only to PCI-capable centres, thereby bypassing community hospitals through direct pre-hospital triage and transfer protocols to the nearest PCI capable hospitals.[9,19,20] The role of community hospitals in that concept is restricted, at best, to post-intervention care. The present study highlights a major limitation of such a model: despite an elaborated emergency medical service (EMS) system, a substantial proportion of STEMI patients still present themselves at the nearest community hospitals (without calling the EMS system) or are transported with a local ambulance system (without medical support) to the nearest community hospital. Based on the proportion of patients that were admitted to community hospitals versus those admitted to PCI-capable hospitals, we may assume that those patients represent 35–40% of our total study population, which is in line with other national registries.[21] A closer involvement of the community hospitals in the acute care of STEMI patients, including active participation in the triage of patients with prolonged chest pain, will guarantee a more evidence-based acute care of the global population of STEMI patients. Indeed, over time, the proportion of transferred PCI patients from community hospitals has greatly increased, rising from 60% to 80%, at the cost of less thrombolysis and also fewer cases in which patients are conservatively managed. In addition, there was a modest but significant improvement in door-to-balloon times. In the present study, these improvements in healthcare did not, however, translate into an improvement in in-hospital mortality. The following reasons may explain our lack of observed effects on mortality: the proportion of transferred pPCI patients in the first study period from 2007 to 2008 was already relatively high (60%) whereas the proportion of conservatively managed STEMI patients was low (as compared to the previously mentioned registries). Thrombolysis was mainly selected for low-risk patients (70% of the patients had a TIMI risk score <4). It has been demonstrated that the mortality benefit of pPCI over thrombolysis is marginal for low-risk STEMI patients.[22,23] Those factors may explain the relatively low mortality rate during the first period, which limit the possibilities to further improve survival. Although further optimisation of transfer times may provide some additional beneficial effect on outcome, the greatest survival benefit can be expected through the prevention of late presenters. The mortality risk of late presenters (who were not amenable for immediate reperfusion therapy) was more than double the risk of STEMI patients who received reperfusion therapy within 4 hours of the onset of pain.

The mortality of thrombolysis in PCI hospitals was unexpectedly high and can only partly be explained by a higher TIMI risk profile. Most likely other factors that were not recorded in the database (such as frailty, renal failure or other conditions that contraindicate invasive interventions) might have played an important role in selecting patients for reperfusion therapy and might have increased the risk profile of those patients.

The results of this study should be considered in the context of the following limitations. Although the study design called for consecutive enrolment of STEMI patients, underreporting cannot be excluded and may have created a selection bias. We minimised this effect by organising audits in each of the participating hospitals and by correcting outcome parameters for different risk factors. In addition, the average mortality of 7% in our study population is in accordance with mortality rates of STEMI patients from other recent nationwide registries.[3,2,24]

In conclusion, the present study indicated that in the context of a STEMI network with a low threshold for invasive evaluation (>70% use of pPCI), the short-term prognosis of STEMI patients admitted to community hospitals is comparable to PCI-capable hospital-admitted patients. These findings strongly support the promotion and the implementation of STEMI networks in all areas with a limited availability of PCI-capable hospitals.

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Conflict of interest

None declared.

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