



# Primary angioplasty in acute myocardial infarction with right bundle branch block: should new onset right bundle branch block be added to future guidelines as an indication for reperfusion therapy?

Petr Widimsky<sup>1\*</sup>, Filip Roháč<sup>1</sup>, Josef Štásek<sup>2</sup>, Petr Kala<sup>3</sup>, Richard Rokyta<sup>4</sup>, Boyko Kuzmanov<sup>5</sup>, Martin Jakl<sup>2</sup>, Martin Poloczek<sup>3</sup>, Jan Kaňovský<sup>3</sup>, Ivo Bernat<sup>4</sup>, Ota Hlinomaz<sup>6</sup>, Jan Bělohávek<sup>7</sup>, Ales Král<sup>7</sup>, Vratislav Mrázek<sup>7</sup>, Vladimír Grigorov<sup>8</sup>, Slaveyko Djambazov<sup>5</sup>, Robert Petr<sup>1</sup>, Jiri Knot<sup>1</sup>, Dana Bílková<sup>1</sup>, Michaela Fischerová<sup>1</sup>, Karel Vondrák<sup>1</sup>, Marek Malý<sup>9</sup>, and Alena Lorencová<sup>1</sup>

<sup>1</sup>Cardiology Department, Third Faculty of Medicine, Charles University Prague, University Hospital Kralovske Vinohrady, Srobarova 50, Prague 10, Czech Republic; <sup>2</sup>Faculty of Medicine Hradec Kralove, Czech Republic; <sup>3</sup>Medical Faculty, Masaryk University and University Hospital Brno, Czech Republic; <sup>4</sup>Faculty of Medicine Plzen, Charles University Prague, Czech Republic; <sup>5</sup>Bulgarian Cardiology Institute, Plevan, Bulgaria; <sup>6</sup>University Hospital St Anne, Brno, Czech Republic; <sup>7</sup>First Faculty of Medicine, Charles University Prague, Czech Republic; <sup>8</sup>Cardiac Center Johannesburg, South Africa; and <sup>9</sup>National Institute of Public Health, Prague, Czech Republic

Received 3 January 2011; revised 25 June 2011; accepted 25 July 2011

## Aims

The current guidelines recommend reperfusion therapy in acute myocardial infarction (AMI) with ST-segment elevation or left bundle branch block (LBBB). Surprisingly, the right bundle branch block (RBBB) is not listed as an indication for reperfusion therapy. This study analysed patients with AMI presenting with RBBB [with or without left anterior hemiblock (LAH) or left posterior hemiblock (LPH)] and compared them with those presenting with LBBB or with other electrocardiographic (ECG) patterns. The aim was to describe angiographic patterns and primary angioplasty use in AMI patients with RBBB.

## Methods and results

A cohort of 6742 patients with AMI admitted to eight participating hospitals was analysed. Baseline clinical characteristics, ECG patterns, coronary angiographic, and echocardiographic data were correlated with the reperfusion therapies used and with in-hospital outcomes. Right bundle branch block was present in 6.3% of AMI patients: 2.8% had RBBB alone, 3.2% had RBBB + LAH, and 0.3% had RBBB + LPH. TIMI flow 0 in the infarct-related artery was present in 51.7% of RBBB patients vs. 39.4% of LBBB patients ( $P = 0.023$ ). Primary percutaneous coronary intervention (PCI) was performed in 80.1% of RBBB patients vs. 68.3% of LBBB patients ( $P < 0.001$ ). In-hospital mortality of RBBB patients was similar to LBBB (14.3 vs. 13.1%,  $P = 0.661$ ). Patients with new or presumably new blocks had the highest (LBBB 15.8% and RBBB 15.4%) incidence of cardiogenic shock from all ECG subgroups. Percutaneous coronary intervention was done more frequently (84.8%) in patients with new or presumably new RBBB when compared with other patients with blocks (old RBBB 66.0%, old LBBB 62.3%, new or presumably new LBBB 73.0%). In-hospital mortality was highest (18.8%) among patients presenting with new or presumably new RBBB, followed by new or presumably new LBBB (13.2%), old LBBB (10.1%), and old RBBB (6.4%). Among 35 patients with acute left main coronary artery occlusion, 26% presented with RBBB (mostly with LAH) on the admission ECG.

\* Corresponding author. Tel: +420 267163159, Fax: +420 267162621, Email: [widim@fnkv.cz](mailto:widim@fnkv.cz)

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## Conclusion

Acute myocardial infarction with RBBB is frequently caused by the complete occlusion of the infarct-related artery and is more frequently treated with primary PCI when compared with AMI + LBBB. In-hospital mortality of patients with AMI and RBBB is highest from all ECG presentations of AMI. Restoration of coronary flow by primary PCI may lead to resolution of the conduction delay on the discharge ECG. Right bundle branch block should strongly be considered for listing in future guidelines as a standard indication for reperfusion therapy, in the same way as LBBB.

## Keywords

Acute myocardial infarction • Right bundle branch block • Left bundle branch block • Primary angioplasty • Reperfusion

## Introduction

Left bundle branch block (LBBB) and right bundle branch block (RBBB) in acute myocardial infarction (AMI) patients are well known to carry the high mortality risk.<sup>1,2</sup> Nevertheless, the guidelines of the European Society of Cardiology (ESC) list only LBBB as an indication for urgent reperfusion therapy.<sup>3</sup> The American Heart Association (AHA)/American College of Cardiology (ACC) guidelines provide similar recommendations.<sup>4</sup> Thus, the current guideline-recommended electrocardiographic (ECG) indications for reperfusion therapy in AMI include ST-segment elevation (STE) and LBBB of new or unknown onset. It is not well known whether also new or unknown onset RBBB should be an indication for reperfusion therapy, especially in the modern era of primary percutaneous coronary intervention (PCI). The aim of this analysis was to investigate the coronary angiographic (CAG) findings, reperfusion therapies used, and

in-hospital outcomes of patients with AMI presenting with RBBB when compared with those presenting with LBBB or with other ECG patterns.

## Methods

### Patients

A total of 6742 consecutive patients with AMI routinely admitted to eight participating tertiary hospitals during the study period of 3 years (2006–08) were retrospectively analysed. The patients were included in this retrospective registry based on (i) diagnosis of AMI and (ii) coronary angiography. Patients with AMI, who did not undergo coronary angiography ( $n = 650$ , i.e. 8.8% from all AMI patients), are not subject of this analysis. Baseline characteristics studied (age, sex, diabetes, previous myocardial infarction, Killip class on admission, etc.) are listed in *Table 1*.

**Table 1** Patients baselines characteristics

	STEMI	STDMI	LBBB	RBBB	Other ECG	P-value*	P-value**
$n = 6742$	3447	907	291	427	1670		
Mean age (years)	64.5 (12.4)	69.5 (10.7)	72.1 (10.1)	69.8 (11.3)	65.6 (11.4)	0.005	<0.001
Females (%)	31.2	34.6	38.1	23.2	31.6	<0.001	<0.001
Diabetes (%)	24.0	36.8	45.7	36.3	31.7	0.013	<0.001
Previous MI (%)	13.8	29.2	38.1	25.8	29.7	<0.001	<0.001
Killip class (mean)	1.44 (0.85)	1.47 (0.83)	1.86 (1.06)	1.71 (1.01)	1.23 (0.62)	0.050	<0.001
Killip I (%)	72.6	70.5	51.2	57.9	84.5	0.134	<0.001
Killip II (%)	17.0	16.0	24.6	24.1	9.9		
Killip III (%)	3.7	9.1	11.1	6.9	3.3		
Killip IV (%)	6.7	4.4	13.1	11.1	2.3		
Old BBB (%)	–	–	26.7	26.5	–	0.508	–
Unknown BBB (%)	–	–	57.5	60.8	–		
New BBB (%)	–	–	15.8	12.7	–		
QRS mean (ms)	–	–	133.7 (19.6)	133.4 (18.9)	–	0.811	–
BBB disappeared (%)	–	–	14.2	18.8	–	0.193	–
Median duration of the hospital stay	5	6	5	7	4	0.001	<0.001

Continuous data are expressed as mean values (standard deviation), categorical data are expressed as relative frequencies (percentage).

STEMI, ST elevation myocardial infarction; STDMI, ST depression myocardial infarction; LBBB, left bundle branch block; RBBB, right bundle branch block; ECG, electrocardiogram; MI, myocardial infarction; BBB, bundle branch block; QRS, QRS complex on ECG.

\*P-value only applies to the comparison of LBBB vs. RBBB.

\*\*P-values for the comparison of all five groups (null hypothesis: all five groups have the same characteristics).

## Electrocardiographic patterns

Electrocardiographic reading was done by the treating cardiologist. Electrocardiograms from all patients with RBBB have been reviewed once more at the time of this manuscript preparation by another independent cardiologist. The patients were divided into the following subgroups based on the first (admission) ECG:

- (i) ST-segment elevation acute myocardial infarction (STEMI,  $n = 3447$ , i.e. 51.1%): persistent STEs in at least two contiguous leads ( $\geq 2$  mm in the chest leads or  $\geq 1$  mm in the extremity leads),
- (ii) ST-segment depression acute myocardial infarction (STDAMI,  $n = 907$ , i.e. 13.5%): horizontal or descending ST-segment depressions in at least two contiguous leads ( $\geq 2$  mm in the chest leads or  $\geq 1$  mm in the extremity leads),
- (iii) acute myocardial infarction with LBBB, irrespective of any ST-segment deviations were present on ECG (LBBB-MI,  $n = 291$ , i.e. 4.3%): QRS  $\geq 120$  ms and LBBB shape,
- (iv) acute myocardial infarction with RBBB, irrespective of any ST-segment deviations were present on ECG (RBBB-MI,  $n = 427$ , i.e. 6.3%) with subgroups of RBBB alone (2.8%), RBBB + left anterior hemiblock (LAH) (3.2%), RBBB + left posterior hemiblock (LPH) (0.3%): QRS  $\geq 120$  ms and RBBB shape, electrical axis extreme left ( $> -45^\circ$ ) for LAH, respectively, extreme right ( $> +105^\circ$ ) for LPH. In all RBBB patients, a special care was taken to describe the presence or absence of STEs and all ECGs were once more analysed by an independent cardiologist.
- (v) acute myocardial infarction with other ECG (other ECG-MI,  $n = 1670$ , i.e. 24.8%): any other ECG patterns (negative T waves, small ST shifts not fulfilling the above criteria, non-specific or even negative ECG).

The information whether any bundle branch block (BBB) is old, new, or unknown origin and whether BBB persisted or disappeared during the hospital stay was collected. Analyses in this manuscript are done with all RBBB (including bifascicular blocks) as one patient group (i.e. RBBB  $\pm$  LAH or LPH).

## Coronary angiography, reperfusion therapy, outcomes

Coronary angiographic or autopsy data were analysed to estimate the number of diseased major coronary arteries, to identify the infarct-related artery, and to analyse TIMI flow in the infarct-related artery before and after percutaneous coronary intervention (PCI, whenever it was performed). Coronary angiography was described by the interventional cardiologist, who performed the procedure. Pre-discharge echocardiographic ejection fraction was registered. Reperfusion therapies used during the initial hospital stay and in-hospital mortality were analysed.

## Statistical analysis

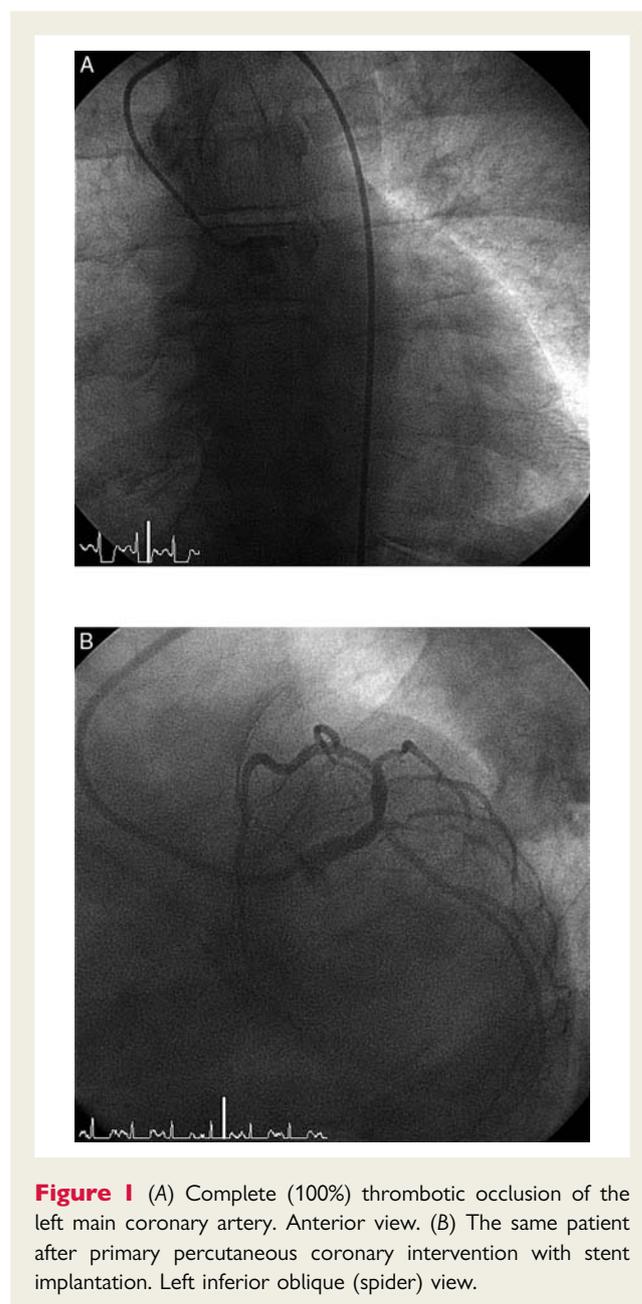
For continuous variables, mean values and standard deviations were calculated. After checking normality by the Shapiro–Wilk test, Student's *t*-test was used for testing of the hypotheses about the means when two groups (RBBB and LBBB) were compared. The analysis of variance was used for comparison of more than two groups. The Mann–Whitney test was used for the ordinal variables. Categorical data were tested with the Fisher's exact test and Pearson's  $\chi^2$ -test and adjusted residuals were used to identify significantly different subcategories. The multiple logistic regression and Cox's proportional hazards models were used to adjust the differences among groups for confounding factors. Following factors

and covariates were entered into model: age, gender, indicators of diabetes, and previous MI, Killip class. Odds ratio (OR), hazard ratio (HR), and corresponding 95% confidence intervals (95% CI) are presented as effect estimates. All tests have been performed as two-sided on the level of significance 0.05. Statistical software Stata, release 9.2 (Stata Corp LP, College Station, TX, USA) was used for the analysis.

## Results

### Coronary angiographic findings

TIMI flow 0 (Figure 1) in the infarct-related artery was present in 51.7% of RBBB patients vs. 39.4% of LBBB patients [OR = 1.64 (95% CI 1.14–2.32),  $P = 0.023$ ; adjusted OR 1.76 (95% CI 1.31–2.53),



**Figure 1** (A) Complete (100%) thrombotic occlusion of the left main coronary artery. Anterior view. (B) The same patient after primary percutaneous coronary intervention with stent implantation. Left inferior oblique (spider) view.

**Table 2** Angiographic findings, reperfusion therapy, and outcomes

	STEMI	STDMI	LBBB	RBBB	Other ECG	P-value*	P-value**
n= 6742	3447	907	291	427	1670		
No signif. CAD (%)	0.8	0.1	2.2	2.2	2.6	0.214 <sup>a</sup>	<0.001 <sup>a</sup>
1-VD	37.3	17.2	21.3	27.8	29.1		
2-VD	28.2	19.9	28.3	30.1	27.5		
3-VD	30.0	53.1	41.9	35.5	35.1		
LM disease	3.7	9.7	6.3	4.4	5.7		
IRA—LMCA (% from IRAs)	1.1	6.0	5.8	3.5	2.3	0.281	<0.001
IRA-LAD	45.0	31.5	43.8	48.5	42.7		
IRA-LCX	14.0	37.5	22.1	17.2	24.0		
IRA-RCA	39.1	21.2	25.8	28.9	27.5		
IRA-bypass	0.8	3.8	2.5	1.9	3.5		
No PCI done (% of all)	10.8	38.2	31.7	19.9	32.5	<0.001	<0.001
Pre-PCI TIMI flow 0 (% from PCIs)	57.3	22.5	39.4	51.7	20.5	0.023	<0.001
TIMI-1	8.4	5.9	8.0	8.6	6.7		
TIMI-2	18.8	24.7	23.9	19.3	19.5		
TIMI-3	15.5	46.9	28.6	20.4	53.3		
Post-PCI TIMI flow 0-1 (% from PCIs)	4.4	3.8	9.6	7.0	4.2	0.409	<0.001
TIMI-2	6.4	1.7	7.5	10.0	2.4		
TIMI-3	89.2	94.5	82.9	83.0	93.4		
Reperfusion—none (%)	10.9	30.2	29.0	17.7	28.9	0.002	<0.001
TL (%)	0.4	0.0	0.3	0.5	0.0		
Primary PCI (%)	88.1	61.8	68.3	80.1	67.5		
Acute CABG (%)	0.6	8.0	2.4	1.7	3.6		
Mean EF (%)	46.3 (12.0)	50.1 (13.5)	37.5 (12.7)	42.4 (14.2)	53.4 (13.1)	<0.001	<0.001
In-hospital mortality (%)	5.4	6.3	13.1	14.3	2.9	0.661	<0.001

Continuous data are expressed as mean values (standard deviation), categorical data are expressed as relative frequencies (percentage).

STEMI, ST elevation myocardial infarction; STDMI, ST depression myocardial infarction; LBBB, left bundle branch block; RBBB, right bundle branch block; ECG, electrocardiogram; CAD, coronary artery disease; 1-VD, single vessel disease; 2-VD, two vessel disease; 3-VD, three vessel disease; LM, left main; IRA, infarct related artery; LMCA, left main coronary artery; LAD, left anterior descending; LCX, left circumflex; RCA, right coronary artery; PCI, percutaneous coronary intervention; TIMI, thrombolysis in myocardial infarction; TL, thrombolysis; CABG, coronary artery bypass grafting; EF, ejection fraction.

<sup>a</sup>None of CAD (no signif., 1,2,3-vessel) and LM disease categories differs significantly (all  $P > 0.05$ ) in the comparison of LBBB vs. RBBB; all categories differ significantly (all  $P < 0.001$ ) among five compared groups.

\*P-value only applies to the comparison of LBBB vs. RBBB.

\*\*P-values for the comparison of all five groups (null hypothesis: all five groups have the same characteristics).

$P = 0.005$ ]. Nearly 80% of RBBB patients had a complete or sub-total occlusion of the infarct-related artery (TIMI flow 0-2 was present in 79.6% of RBBB AMI patients). Furthermore, the distribution of TIMI flow grades among RBBB patients closely resembled the pattern seen among ST elevation group and this angiographic similarity between STEMI and RBBB was more distinct than between STEMI and LBBB (Table 2).

### Left main coronary artery occlusion

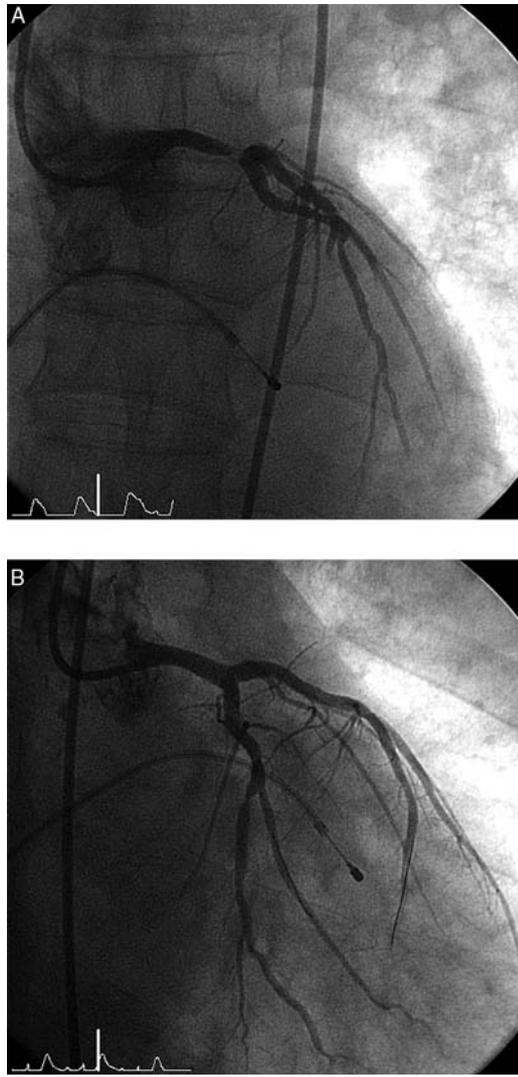
Ninety-seven patients (1.4% of the entire study population) had left main, as the infarct-related, artery (Figure 2). In 35 of them, the left main coronary artery (LMCA) was functionally occluded (TIMI flow 0–2): most frequent ECG presentation pattern for LMCA occlusion was STE ( $n = 17$ ), followed by RBBB [ $n = 9$ ; with LAH in six patients (Figures 3 and 4) and without LAH in three patients], LBBB ( $n = 6$ ), and ST-segment depression ( $n = 3$ ). In other words, acute LMCA occlusion presents in 26% with RBBB, without STEs (Figure 5).

### Reperfusion therapies

Primary PCI was performed in 80.1% of RBBB patients vs. 68.3% of LBBB patients [OR = 1.88 (95% CI 1.33–2.64),  $P < 0.001$ ; adjusted OR = 1.71 (95% CI 1.19–2.45),  $P = 0.004$ ]. This difference was caused by the fact that fewer LBBB patients had CAG findings suitable for primary PCI (see Table 2 for details). In STEMI patients primary PCI was performed in 88.1%.

### In-hospital outcomes

Despite the fact that RBBB patients were younger, had less frequent diabetes, less severe CAG findings, and less previous AMIs than LBBB patients, RBBB was related with a similar mortality as LBBB [14.3 vs. 13.1%, HR = 1.17 (95% CI 0.72–1.90),  $P = 0.630$ ; adjusted HR = 1.33 (95% CI 0.80–2.21),  $P = 0.268$ ] and was more than twice the mortality of STEMI [5.4%, HR = 2.11 (95% CI 1.45–3.07),  $P < 0.001$ ; adjusted HR = 1.80 (95% CI 1.21–2.68),  $P = 0.004$ ] and STDMI [6.3%, HR = 2.49



**Figure 2** (A) Subtotal (99%) left main coronary artery occlusion. Anterior view. (B) The same patient after primary percutaneous coronary intervention with two stents (kissing technique) implantation. Right inferior oblique view.

(95% CI 1.70–3.64),  $P < 0.001$ ; adjusted HR = 1.44 (95% CI 0.92–2.27),  $P = 0.108$ ], respectively (Table 2).

### Relation between in-hospital mortality and duration of the hospital stay

Even after taking the length of hospital stay into account, the conclusions concerning in-hospital mortality remain unchanged. We have tried the logistic regression model with length of hospital stay as a covariate and Cox's model. The overall test is significant ( $P$ -value for the comparison of all five groups  $P < 0.001$ ). The comparison RBBB vs. LBBB yields  $P = 0.686$ , so the adjustment for length of stay brings only very small shift compared with the  $P$ -value presented in Table 2. The  $P$ -values for other contrasts involving RBBB group are: RBBB vs. STEMI  $P < 0.001$ , RBBB vs. ST/MI  $P = 0.014$ , RBBB vs. other ECG  $P < 0.001$ . In fact, the

median duration of hospital stay among the deceased patients was short (2 days for RBBB and 2.5 days for LBBB), confirming the clinical experience that vast majority of fatalities occurs within initial 48–72 h after hospital admission.

### Bundle branch block onset time

Patients with BBBs were further divided according to the BBB onset time (Table 3): new or presumably new BBB (as this is the currently accepted indication for reperfusion therapy in LBBB) vs. BBB known to be old. Group of patients with new or presumably new RBBB (despite having the lowest mean age from all BBB subgroups) had high Killip class on admission (15.4% presenting with cardiogenic shock). TIMI flow 0 in the infarct-related artery was found in significantly more patients with new or presumably new RBBB (55%) than in other three subgroups (old RBBB 34.9%, old LBBB 28%, new or presumably new LBBB 41.1%). Percutaneous coronary intervention was performed in 84.8% of patients with new or presumably new RBBB, more than in other three subgroups (old RBBB 66%, old LBBB 62.3%, new or presumably new LBBB 73%). The most striking are mortality differences between these four subgroups: in-hospital mortality was highest (18.8%) among patients presenting with new or presumably new RBBB, followed by new or presumably new LBBB (13.2%), old LBBB (10.1%), and old RBBB (6.4%).

### Disappearance of bundle branch block during the hospital stay

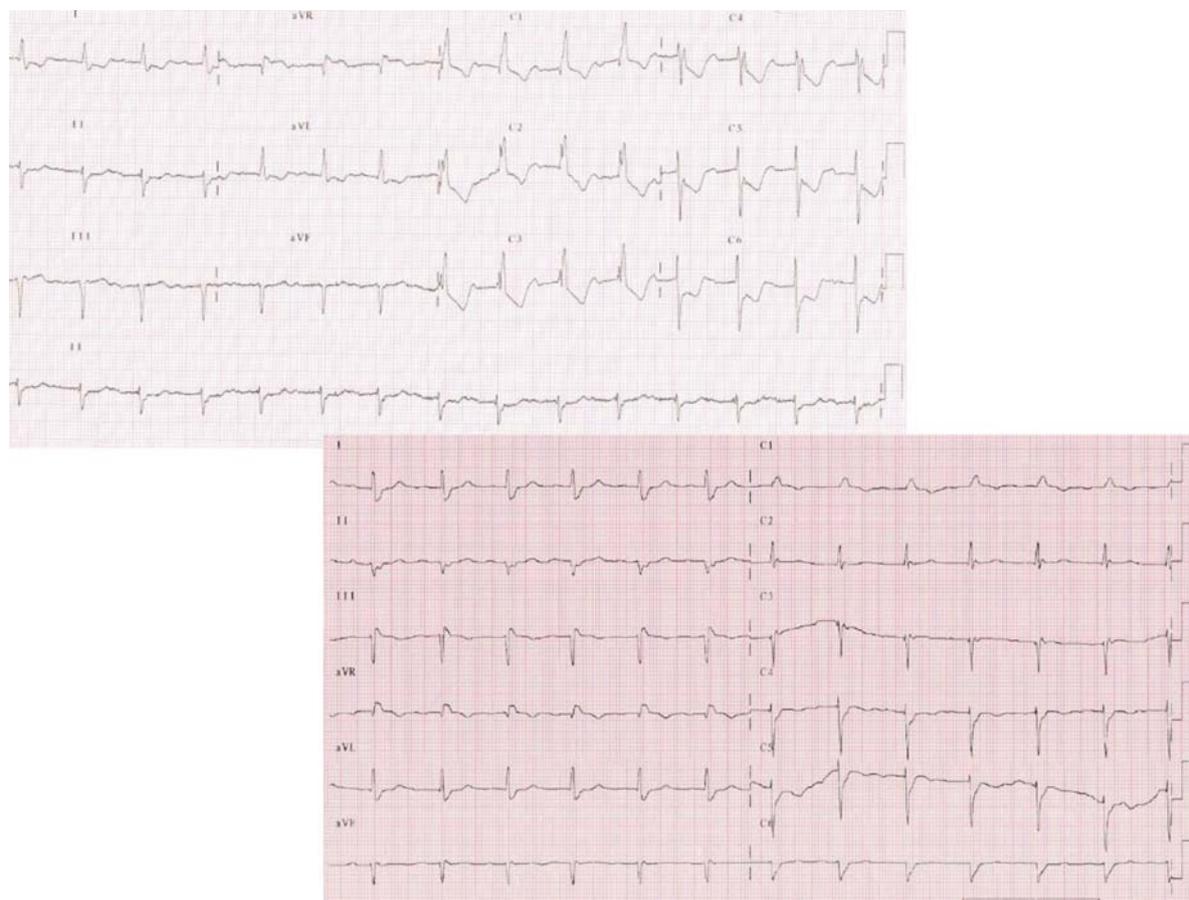
In 87 patients, the BBB (present on the admission ECG) disappeared during the hospital stay. Almost all these patients had BBB of new or unknown onset and they mostly presented to hospital with acute heart failure (mean Killip class was 1.93, cardiogenic shock was present in 19%, 86% were treated by primary PCI, which was successful in 98%). Left bundle branch block disappeared in 32 patients and their mortality was 6.2%. Right bundle branch block disappeared in 55 patients and their mortality was 12.7%.

### Bifascicular blocks

Patients, in whom RBBB was combined with either LAH or LPH tended to be older, had higher incidence of diabetes, had lower ejection fraction, more frequent occurrence of three-vessel disease and LAD as an infarct-related artery, and had slightly higher mortality (Table 4).

### Right bundle branch block and ST-segment elevations

ST-segment elevations (as defined in the methods section) were recognizable on electrocardiograms of 226 (53%) RBBB patients, while in 201 (47%) of patients presenting with AMI and RBBB no STEs could be found. TIMI flow 0–2 was found on emergent coronary angiography among 135 (67%) patients with RBBB and no STEs and 205 (91%) of those who had RBBB and STEs.



**Figure 3** Electrocardiography from two patients admitted in Killip class II-III with acute 100% occlusion of the left main coronary artery (A) and proximal dominant right coronary artery (B).

## Discussion

### Outcomes of acute myocardial infarction patients with bundle branch block

Historically, the mortality of patients with AMI and RBBB before the thrombolytic era reached 77%.<sup>5</sup> A more recent study from Denmark still revealed the highest mortality of AMI among patients with BBB (left or right): 33.3% patients died in-hospital and 54.8% were dead at 1 year.<sup>6</sup> In the study of Dubois et al.,<sup>7</sup> patients with BBB (both left and right) had more complications and higher Killip class on admission. Both in-hospital mortality (32 vs. 10%,  $P < 0.001$ ) and 3-year mortality (37 vs. 18%,  $P < 0.001$ ) were higher among patients with complete BBB. In one study of 1238 consecutive patients with AMI,<sup>8</sup> RBBB was found in 10.9% of patients. It was newly diagnosed in 37.8%, was known to be old in 34.1%, and in 28.1% the time of RBBB origin could not be established. Right bundle branch block patients had 1-year mortality 40.7 vs. 17.6% mortality in patients without RBBB ( $P < 0.001$ ). Mortality was significantly higher for new RBBB (43.1%,  $P < 0.001$ ) than for old (15.5%) and indeterminate (15.3%) RBBB. For isolated RBBB vs. bifascicular block, early mortality was 14.4 vs. 40.6%, and 1-year mortality was 30.2 vs. 54.2% ( $P < 0.05$  for both).

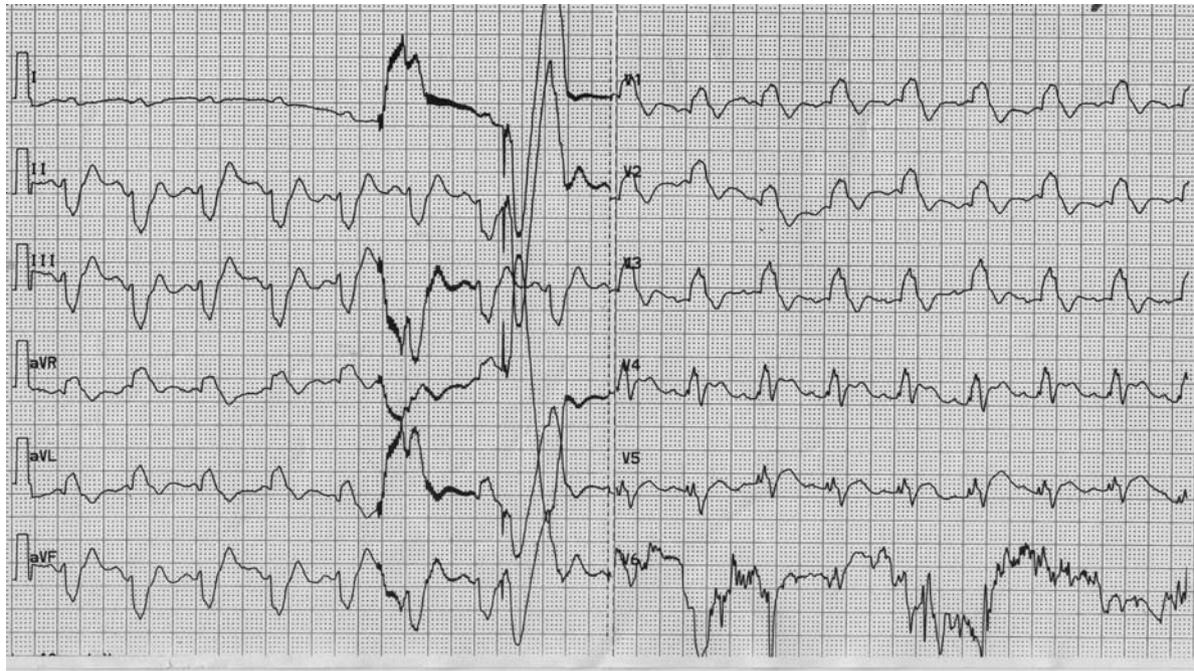
Multivariate analysis showed an independent prognostic value of RBBB for early and 1-year mortality.

### Bundle branch block onset time

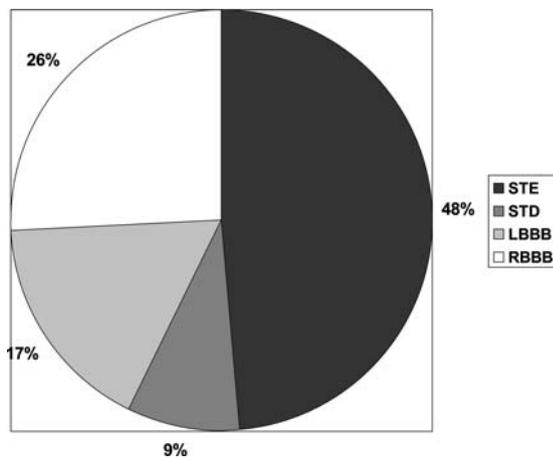
In the usual clinical reality (at the time of decision for urgent CAG procedure), BBB frequently cannot be securely established as new or old. Thus, patients without information about previous ECG are described as 'BBB of unknown origin' and were evaluated together with patients in whom previous ECG did not show BBB.

### Right bundle branch block in the guidelines

The ESC and AHA/ACC guidelines<sup>3,4</sup> were discussed in the introduction part. These guidelines surprisingly do not list new (or unknown) onset RBBB as an indication for reperfusion therapy. Interestingly, the guidelines of the American College of Emergency Physicians for the management of patients with suspected AMI or unstable angina<sup>9</sup> recommend reperfusion therapy in presence of any type of BBB. This recommendation is based on the GISSI<sup>10</sup> and ISIS-2 studies.<sup>11</sup> Also the Czech Society of Cardiology guidelines from 2009<sup>12</sup> recommend



**Figure 4** Electrocardiographic from a 66-year-old male acute myocardial infarction patient with cardiogenic shock, subtotal left main coronary artery occlusion, and TIMI flow 2. Again, ST-segment elevation in V4–V5 is not typical and can easily be overlooked, while the dominant feature of this Electrocardiography is wide QRS complex deformed by RBBB + LAH.



**Figure 5** Electrocardiographic findings among patients with acute myocardial infarction caused by the left main coronary artery occlusion.

primary PCI strategy for all patients with new (or presumably new) BBB (left or right).

### Bundle branch blocks and thrombolysis

The absolute mortality reduction from thrombolysis was greatest among patients presenting with any BBB (−4.9%), followed by

anterior STE (−3.7%), ST elevation ‘other’ (−2.8%), ST depression (−1.4%), and ST elevation inferior (−0.9%).<sup>13</sup> The analysis of the GUSTO 1 and TAMI 9 cohorts<sup>14</sup> found that left anterior descending (LAD) artery infarcts account for 54% of all new BBBs and among anterior infarcts RBBB was more common (13%) than LBBB (7%). Thrombolytic therapy reduced mortality among patients with both BBBs (left and right).

### Bundle branch blocks and primary percutaneous coronary intervention

Kurusu *et al.*<sup>15</sup> in patients with anterior myocardial infarction found significantly higher 30-day mortality in patients with RBBB compared with those without RBBB (14.0 vs. 1.9%,  $P < 0.01$ ). The study of Kleeman *et al.*<sup>16</sup> found that patients presenting with RBBB had higher in-hospital (26 vs. 11%,  $P < 0.001$ ) and post-discharge (19 vs. 9.2%,  $P < 0.001$ ) mortality than patients without RBBB. After adjustment for differences in baseline characteristics, RBBB remained an independent predictor of increased mortality. Sakakura *et al.*<sup>17</sup> retrospectively analysed a group of 25 patients with AMI caused by the LMCA occlusion. The in-hospital mortality was 60%. Logistic regression analysis found RBBB as an independent predictor of mortality. Hirano *et al.*<sup>18</sup> found that 37% of patients with AMI caused by the LMCA occlusion present with RBBB, while only 3% with LBBB. We have shown that acute LMCA occlusion presents in 26% only with RBBB without STEs (Figure 5) being in close accordance both to previously mentioned reports and with Hirano *et al.*, who found that in 30% of LMCA occlusions no STE could be found on the admission ECG, while RBBB with left axis deviation (frequently

**Table 3** Bundle branch block onset time

	LBBB old	LBBB new or unknown onset	RBBB old	RBBB new or unknown onset	P-value
% from all patients	1.1	3.2	1.7	4.6	
Mean age (years)	71.1 (10.0)	71.4 (10.1)	72.2 (9.9)	69.3 (11.5)	0.004
Killip class (mean)	1.68 (0.98)	1.94 (1.10)	1.45 (0.77)	1.88 (1.10)	0.001
Killip IV (%)	8.8	15.8	4.3	15.4	0.011
BBB disappeared (%)	1.6	19.4	6.8	23.2	<0.001
Pre-PCI TIMI flow 0 (% from PCIs)	28.0	41.1	34.9	55.0	<0.001
No PCI done (% of all)	37.7	27.0	34.0	15.2	<0.001
Reperfusion—none (%)	33.3	24.3	31.9	12.5	<0.001
Primary PCI (%)	62.3	73.0	66.0	84.8	
Mean EF (%)	37.3	37.8	43.4	41.5	0.003
In-hospital mortality (%)	10.1	13.2	6.4	18.8	0.015

P-value refers to the comparison of all four groups (null hypothesis: all four groups have the same characteristics). Continuous data are expressed as mean values (standard deviation), categorical data are expressed as relative frequencies (percentage). Abbreviations same as in Tables 1 and 2.

accompanied by ST-elevation in aVR) is typical for this catastrophic type of AMI. Another study<sup>19</sup> found RBBB even in 52% of patients with acute occlusion of the LMCA.

In the PAMI trials,<sup>20</sup> patients with LBBB (1.6%) on presenting electrocardiogram were compared with patients who had RBBB (3.1%) or no BBB (95.3%). In-hospital mortality was highest with LBBB 14.6%, followed by RBBB 7.4% and no BBB 2.8% ( $P < 0.0001$ ).

### Right bundle branch block and ST-segment shifts/Q waves

Some authors<sup>2,21</sup> request for the diagnosis of AIM with RBBB other ECG changes (e.g. ST-segment elevations) to be present, while this is not the case for LBBB (where it is generally accepted that LBBB masks ST-segment shifts). Right bundle branch block is thought not to mask the repolarization phase changes or Q waves, therefore other ECG changes have to be present to conclude the diagnosis of AIM. However, others<sup>22</sup> warn before this 'clear-cut' opinion pointing out that minor ST elevations in the anterior leads (V1–V4) can be missed due to compensation by pseudo-normalization of the negative T waves. Our experience showed that even in large infarcts (caused by left main or proximal LAD coronary artery occlusion) bifascicular block (RBBB + LAH or rarely RBBB + LPH) may occur without typical STEs and thus a large life threatening AMI might be missed when ST elevations are required. Authors of this study repeatedly experienced mistakes in the clinical decision making in the real life practice, when patients with ischaemic symptoms and new or presumably new RBBB (but without STEs) were neither referred to urgent coronary angiography  $\pm$  PCI nor treated by thrombolysis, sometimes with catastrophic consequences. This bad experience was the actual trigger for this study.

It has been also shown that interpretation of Q-waves can be tricky in the presence of RBBB.<sup>23</sup> Gussak et al.<sup>24</sup> showed that

RBBB after myocardial infarction shortened Q wave duration, thus enabling false-negative diagnosis of inferior myocardial infarction. Also the term 'RBBB-dependent Q-wave' was introduced by Rosenbaum et al.,<sup>25</sup> who described appearance of new Q waves in leads V1–V2 that disappeared after restoration of normal conduction. Thus false-positive and false-negative diagnosis of myocardial infarction can be made when describing ECG with RBBB in suspicion of myocardial infarction.

### Study limitations

The main study limitation is a retrospective character of analysis. However, all participating centres enrol AMI patients to their own or nationwide registries, thus minimizing the risk of losing a subject from analysis. Another limitation relates to the fact that coronary angiography analysis was not performed in a core lab and by blinded manner. However, we have analysed 'real life' data similar to other registries published and this is not a comparison of different treatment approaches.

### Conclusions

Acute myocardial infarction with new or presumably new RBBB on the admission ECG is frequently related with complete occlusion of the infarct-related artery and with primary PCI treatment when compared with AMI + LBBB. In-hospital mortality of patients with AMI and new or presumably new RBBB (especially when the block is bifascicular) is highest from all ECG presentations of AMI. Restoration of coronary flow by primary PCI may lead to resolution of RBBB on the discharge ECG.

New or presumably new RBBB ( $\pm$  LAH or LPH) should be listed in future guidelines as a standard indication (possibly class I, level C) for reperfusion therapy, in the same way as LBBB, i.e. irrespective of the presence or absence of ST-segment denivelations.

**Table 4** Right bundle branch block with/without left anterior/posterior hemiblock

	RBBB alone	RBBB + LAH	RBBB + LPH	P-value
% from all patients	2.8	3.2	0.3	
Mean age (years)	68.4 (11.6)	71.0 (11.2)	70.8 (9.0)	0.119
Female (%)	22.4	25.4	23.5	0.827
Diabetes (%)	30.9	36.1	29.4	0.588
Previous MI (%)	22.4	26.0	47.1	0.089
Killip class (mean)	1.69 (0.98)	1.59 (0.93)	1.41 (0.80)	0.414
Killip I (%)	57.6	36.9	70.6	0.754
Killip II (%)	26.5	21.1	23.5	
Killip III (%)	5.3	7.2	0.0	
Killip IV (%)	10.6	7.8	5.9	
No signif. CAD (%)	2.1	2.5	0.0	0.935
1-VD	28.5	27.5	17.7	
2-VD	30.5	26.2	29.4	
3-VD	34.7	39.4	52.9	
LM disease	4.2	4.4	0.0	
IRA—LMCA (% from IRAs)	3.8	5.0	0.0	0.006
IRA-LAD	39.4	51.4	38.5	
IRA-LCX	16.7	20.0	23.0	
IRA-RCA	40.1	19.3	38.5	
IRA-bypass	0.0	4.3	0.0	
Pre-PCI TIMI flow 0 (% from PCIs)	53.5	48.5	44.5	0.870
TIMI-1	8.5	9.7	0.0	
TIMI-2	17.1	21.6	22.2	
TIMI-3	20.9	20.2	33.3	
Post-PCI TIMI flow 0-1 (% from PCIs)	6.4	3.7	22.2	0.205
TIMI-2	8.8	11.1	0.0	
TIMI-3	88.8	85.2	77.8	
No PCI done (% of all)	18.7	20.1	52.9	0.008
Reperfusion—none (%)	18.0	17.7	47.1	0.014
TL (%)	0.0	0.0	0.0	
Primary PCI (%)	81.3	79.9	47.1	
Acute CABG (%)	0.7	2.4	5.8	
Mean EF (%)	44.9 (13.5)	42.1 (13.4)	41.2 (18.0)	0.189
In-hospital mortality (%)	10.5	14.8	17.7	0.438

P-value refers to the comparison of all three groups (null hypothesis: all three groups have the same characteristics).

LAH, left anterior hemiblock; LPH, left posterior hemiblock.

Abbreviations others same as in Tables 1 and 2.

## Funding

This study was partially supported by the Charles University Prague research project nr. MSM0021620817. Funding to pay the Open Access publication charges for this article was provided by the Charles University Prague (Third Faculty of Medicine, MSM0021620817).

**Conflict of interest:** none declared.

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