Commentaries

Is Door-to-Balloon Time the Best Metric to Assess Successful Treatment of STEMI?

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In 2011, all cardiologists believe that rapid opening of the infarct-related artery is critical to enhanced survival. The preferred way to open an occluded vessel is percutaneous intervention (PCI), but thrombolytic therapy remains a viable option in hospitals when PCI capability is not immediately available.

Introduction

The current metric that is used to judge appropriate management of acute ST segment elevation myocardial infarction is door-to-balloon (D2B) time. The metric of D2B is easy to measure and can be documented accurately. Cannon and colleagues published data in a cohort of more than 27 000 patients treated with urgent percutaneous coronary intervention and found that D2B times longer than 2 hours was an important factor related to mortality.[1]

D2B time <90 minutes is an acceptable goal. The rationale is that short D2B time results in less myocardial necrosis of myocardium. A favorable outcome correlates well with a small amount of myocardial necrosis and an ejection fraction >40%. An unfavorable outcome correlates well with a large amount of necrosis and an ejection fraction of <40%.[2]

Timing of Vessel Occlusion

Human

Theoretically, in the human, if mortality reduction is plotted against extent of salvage of myocardium from 0 hours to 3 hours, there is a very steep decrement in percent mortality reduction, and by 3 hours the myocardial salvage is markedly reduced.[3] From 3 hours on, the percent mortality reduction is similar to that found at 3 hours. Unfortunately, the exact time of vessel occlusion is not known in the human myocardial infarction.

Experimental Animal

In the experimental laboratory, Reimer and colleagues[4] reported myocardial infarct size vs duration of coronary occlusion in a dog. In this experiment, the circumflex coronary artery, which is the major coronary artery in the dog, was ligated. Thus, the actual time of onset of coronary occlusion was identified, and the time course of myocardial necrosis was measured. Myocardial infarction always started at the subendocardium, where collateral flow is least and spread outward toward the epicardium. In these experimental animals, the investigators noted that the subendocardial zone of severe ischemia dies relatively quickly, but the subepicardial myocardium, although moderately ischemic, dies more slowly and survives. They reported that "myocardial cells in these experimental animals started to die at about twenty minutes after onset of ischemia, and by six hours the killing was complete." The investigators noted there was transmural progression of necrosis within the framework of the ischemic bed (myocardium at risk) and collateral flow. They coined the term "wave front phenomenon" of myocardial ischemic cell death.

There was an inverse relationship between collateral flow and infarct size, an important phenomenon that needs to be considered in human myocardial infarctions, vis-à-vis reperfusion and myocardial salvage and outcome.

Factors That May Influence Outcome in STEMI Patients Prior to Arrival of the Patient in the Hospital

There are other factors present in many myocardial infarction patients that are not so easy to measure but may influence the outcome for the individual patient undergoing urgent PCI or thrombolysis. When the initial electrocardiogram reveals STEMI, other factors that may influence outcome include timing of vessel occlusion and clinical condition of the patient.

Timing of Vessel Occlusion May Influence Outcome

One can ask the question, when did the vessel occlusion occur? Did it occur when symptoms began, as one could discern in an animal laboratory in which the precise onset of vessel occlusion is known? In the human this is not possible, but one might conclude that perhaps the vessel occlusion was recent if the initial troponin levels were in a normal range. In contrast, if the first troponin drawn was abnormal, it strongly suggests that the vessel occlusion occurred 4 to 6 hours prior to the measurement. This observation may make a difference in terms of outcome despite the fact that the D2B time was <90 minutes in both cases.

Clinical Conditions That May Influence Outcome

- In patients with STEMI who have had a previous infarction, outcome may be worse than in patients who present with their first infarction.
- If chronic angina was present prior to the STEMI, outcome might be better because collaterals may be

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present and associated with the infarct-related artery (IRA) and not as good if collaterals are absent.
- If the STEMI patient had new onset of angina at rest vs new onset of angina with effort, outcome may be poorer in the rest-angina patient.
- If the patient was diabetic and not well controlled, outcome may be poorer than if the patient was not diabetic or was very well controlled.
- If the patient was markedly hypertensive, outcome may be poorer than if the patient was normotensive or well controlled with drugs.
- If the patient had chronic obstructive pulmonary disease, outcome may be poorer than if the patient had normal lung function.

All of these parameters, as far as I can tell, have not really been addressed in the classic papers on D2B time in patients presenting with ST elevation myocardial infarction.

Factors Noted in the Catheterization Laboratory That May Influence Outcome

In the catheterization laboratory during angiography, absence of collaterals to the IRA might portend a poorer outcome than presence of collaterals. If left ventricular ejection fraction is <40%, outcome is poorer than if the ejection fraction is between 40% and 50%.[2]

Factors After PCI

Another parameter that should be considered in addition to D2B time is whether or not the occluded vessel was recannalized and TIMI III flow was established. If the patient was not recannalized or less than TIMI III flow was present, the outcome should be poorer.[5] In that same line of thinking, if there is resolution of the ST segments after recannalization, the outcome should be better than if there is no ECG resolution of ST segments.[6]

So obviously, there are factors that modify what might happen to the individual patient even if D2B time is acceptable (ie, 90 minutes or less).

Conclusion

D2B time is clearly a metric that has been studied quite carefully and correlates well with successful outcomes; however, it does not take into account several factors that might influence the outcome positively or negatively. It seems to me that attention to details of the individual parameters, noted before, during, and after PCI in STEMI patients, might make a difference in outcome and should be considered when metrics of successful management of acute ST segment elevation myocardial infarction are being considered by oversight or regulatory bodies.

Fortunately, D2B time is easy to measure, but unfortunately these other parameters are not so easy to measure. To answer the question posed in the title of this editorial, D2B is a metric, but not necessarily the only metric. Even when D2B time is <90 minutes, other factors may influence the outcome positively or negatively.

As with all aspects of cardiovascular medicine, the substrate (patient's condition) plays a major role when one is comparing a single intervention (ie, revascularization) in STEMI patients whose clinical states are not necessarily identical.

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Correction added after online publication 09 June 2011. The order of citations has been re-sequenced to correspond to the text.

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