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RURAL PATIENT ACCESS TO PRIMARY PERCUTANEOUS CORONARY INTERVENTION CENTERS IS IMPROVED BY A NOVEL INTEGRATED TELEMEDICINE PREHOSPITAL SYSTEM

Alain Tanguay, MD,* Renée Dallaire, PHD,*† Denise Hébert, RN, BSN,* François Bégin, MD,* and Richard Fleet, MD, PHD*†

*Centre hospitalier affilié universitaire Hôtel-Dieu de Lévis, Lévis, Québec, Canada and †Laval University, Québec, Québec, Canada

Reprint Address: Richard Fleet, MD, PHD, CHAU Hôtel-Dieu de Lévis, 143 rue Wolfe, Lévis, QC G6V 3Z1, Canada

□ **Abstract—Background: As per American Heart Association/American College of Cardiology guidelines, the delay between first medical contact and balloon inflation should not exceed 90 min for primary percutaneous coronary intervention (PCI). In North America, few prehospital systems have been developed to grant rural populations timely access to PCI. Objectives: The objective of the present study was to evaluate the ability of an ST-segment elevation myocardial infarction (STEMI) system serving suburban and rural populations to achieve the recommended 90-min interval benchmark for PCI. Methods: A prehospital telemedicine program was implemented in a rural and suburban region of the Quebec province. Three patient groups with STEMI were created according to trajectory: 1) patients already en route to a PCI center, 2) patients initially directed to the nearest hospital who were subsequently diverted to a PCI center during transport, and 3) patients directed to the nearest hospital without transfer for PCI. Time intervals were compared across groups. Results: Of the 208 patients diagnosed with STEMI, 14.9% were already on their way to a hospital with PCI capabilities, 75.0% were rerouted to a PCI center, and 10.1% were directed to the nearest local hospital. All patients but one arrived at the PCI center within the 60-min prehospital care interval, considering an additional 30 min for balloon inflation at the PCI center. Conclusion: This study demonstrated that a regionalized prehospital system for STEMI patients could achieve the recommended 90-min interval benchmark for PCI, while giving timely access to PCI to rural populations that would not otherwise have access to this treatment.**

□ **Keywords—emergency medicine; telemedicine; STEMI; rural health**

INTRODUCTION

The majority of patients with ST-segment elevation myocardial infarction (STEMI) receive greater benefit from rapid reperfusion by primary percutaneous coronary intervention (PCI) than from fibrinolytic therapy (1). However, fibrinolysis is an adequate alternative for patients who do not have timely access to PCI (2). The American College of Cardiology/American Heart Association recommends a maximum delay of 90-min between first medical contact (FMC) and balloon inflation for primary PCI (3). Longer delays were associated with increased readmission due to congestive heart failure, acute myocardial infarction, and mortality (2,4,5). Indeed, timely access to reperfusion seems to be more significant than is treatment strategy in determining outcome.

The development of a coordinated and integrated system of care is designed to permit timely access to

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catheterization facilities, allowing patients to receive appropriate care within the recommended timeframes. The 90-min interval (also known as "system delay") includes two distinct periods: 1) prehospital delay: the interval between FMC and arrival at the PCI center, and 2) door-to-balloon (D2B) interval: the interval between arrival at the PCI center and inflation of the balloon in the catheterization laboratory. The following variables have been demonstrated to reduce D2B delay with respect to prehospital intervals: improvement of prehospital care protocols, with prehospital diagnosis of STEMI by electrocardiogram (ECG) recording and interpretation during ambulance transport; prehospital activation of cardiac catheterization laboratory; direct referral to PCI center without interhospital transfers; and emergency department (ED) bypass at the PCI center (6–13).

By reducing prehospital system delays, new and integrative approaches to STEMI patient care can improve access to PCI in rural populations that would not otherwise have timely access. The objective of the present study was to evaluate whether or not an integrated regional STEMI system serving suburban and rural populations could achieve the 90-min delay benchmark for PCI.

MATERIALS AND METHODS

We conducted this study in the Chaudière-Appalaches region of the province of Quebec (139 municipalities, 15,070 km^2). This region represents approximately 5% of the population of the province, including 403,000 residents in rural (42%) and semi-urban (58%) areas. The area is serviced by four EDs without PCI capabilities, an Emergency Medical Services (EMS) system comprising 46 ambulances and one central agency, and two PCI centers in adjacent regions (Quebec City and Sherbrooke). Prior to 2006, all patients with suspected acute myocardial infarction were systematically transported to the nearest ED. Only patients with STEMI within recommended PCI timeframes were subsequently transferred to a PCI facility.

In 2006, a telemedicine platform called *Unité de coordination clinique de soins préhospitaliers d'urgence* (UCCSPU), affiliated with an academic hospital, was created to improve coordination of EMS patient care in the prehospital setting of our area. This unit permits: 1) acquisition and continuous monitoring of patient medical data during ambulance transportation by telemedicine facilities, 2) direct medical supervision by emergency physicians in the academic hospital, 3) to act as an intermediate between paramedics and the receiving hospitals to improve the efficiency of care delivery. According to these objectives, a telemedicine program was implemented for patients with STEMI: ambulances were equipped with laptops, cell phones, and the necessary equipment for real-time automated ECGs and vital sign transmissions. All patients evaluated by paramedics with chest pain suggestive of cardiac ischemia who met protocol criteria received chewable aspirin and sublingual nitroglycerin, and had 12-lead ECGs prior to and during ambulance transport. Ambulances were not stopped during ECG acquisition. Real-time ECGs and vital signs information were transmitted by modem every 2 min at the UCCSPU. Trained nurses at the UCCSPU collected medical information and interpreted ECGs according to clinical protocols developed by emergency physicians. Abnormal ECGs were immediately interpreted by physicians for STEMI confirmation (a requirement for acceptance at a PCI facility). A diagnosis of STEMI was made if one of the following criteria were met: a) at least 2 mm in two or more contiguous derivations in precordial leads, or b) ST-segment elevation of at least 1 mm in two contiguous peripheral derivations.

Exclusion criteria for direct transfer to PCI were the following: 1) severe terminal disease (i.e., patients receiving palliative care for neoplasia, terminal renal insufficiency, or severe respiratory insufficiency), 2) hemodynamic instability, 3) left bundle-branch block, 4) chest pain or related symptoms lasting more than 12 h, and 5) more than 60-min delay between first positive ECG and catheterization laboratory. For each eligible patient with confirmed STEMI, nurses at the UCCSPU initiated the STEMI bypass protocol and communicated directly with the cardiologist at the catheterization laboratory. In rare cases, cardiologists refused patients for logistical reasons (e.g., number of STEMI patients exceeded catheterization laboratory capacity). Patients with exclusion criteria were directed to the nearest hospital and were evaluated by an emergency physician for risks and benefits of reperfusion treatment: those STEMI patients were offered fibrinolysis, or transfer for PCI, or no treatment at all. All paramedic calls to UCCSPU were recorded for quality-monitoring purposes.

We created a prospective database at the UCCSPU; it contained patients' demographic and medical information as well as transportation time. The study sample included STEMI patients between August 1, 2006 and October 20, 2012. We abstracted travel times from the database at a 911 emergency communication center. We calculated three prehospital intervals between 911 call and arrival at the PCI center or local hospital; 1) time between 911 call and paramedics' arrival on scene, 2) time between paramedics' arrival and first positive ECG for STEMI, and 3) time between positive ECG and arrival at the PCI center or local hospital. D2B interval was previously estimated at 32 min for direct transradial intervention in the main PCI center (Quebec City, 99% of transfers for PCI) (14). We considered, therefore, a 60-