Acute Early Graft Dysfunction Following Off Pump Coronary Surgery: A Case of Air Embolism

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Abstract

Graft patency represents the most relevant issue in coronary surgery, whether on (ONCAB) or off pump (OPCAB). During the last decade major efforts have been made in managing all the multiple factors involved in graft dysfunction, such as more accurate techniques of harvesting and anastomosis, careful graft manipulation, coronary territory distribution and graft quality evaluation. Besides intraoperative graft evaluation have been proposed in order to achieve optimal results. Nevertheless graft dysfunction may occur with inherent complications and sequelae. In these cases, coronary angiography remains the gold standard, since it represents a prompt diagnostic as well as therapeutic solution. In the present case we describe and discuss a temporary acute graft dysfunction, due to air embolism detected by coronary angiography. Since Transit Time Flow Measurement (TTFM) was intra-operatively performed, we investigated additional potentials of TTFM in detecting air embolism.

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Introduction

Carbon dioxide (CO₂) blower improves visualization of the anatomic site in Off Pump Coronary Surgery (OPCAB). Despite of a higher solubility in blood, the use of CO₂ has been associated with potential embolic events in the circulatory system. We herein report a case of gaseous embolism, detected by coronary angiography. Since Transit Time Flow Measurement (TTFM) was intra-operatively performed, we investigated additional potentials of TTFM in detecting air embolism.

Case Report

A 71 year-old woman was hospital admitted owing to exertional angina, in presence of a two-vessel coronary artery disease (Figure 1).

The patient underwent an incomplete revascularization (OPCAB), owing to a too small for grafting obtuse marginal branch (OM). Because of an unfavorable anatomy for a jump graft, in situ Left Internal Mammary Artery (LIMA) was grafted to Left Anterior Descending Artery (LAD), while Saphenous Vein Graft (SVG) was grafted to first diagonal branch (D1) from the ascending aorta. Aortic proximal anastomosis was performed under aortic side-clamping. The two distal anastomoses were performed with an intra-coronary shunt (ClearView® Intracoronary Shunt, Medtronic Inc. 1.75mm and 2.0mm respectively). Before tying the suture, the intra-coronary shunt was retrieved and the graft flushed by removing the proximal bulldog. Carbon dioxide (CO₂) blower (Axius MAQUET Holding B.V. & Co. KG) provided controlled delivery of CO₂ (flow of 4 l/min; pressure of 50mmHg) and saline to improve visibility during anastomosis. Transit Time Flow Measurement; (VeriQ™ Medistim-ASA, Oslo-Norway) was performed twice; after each anastomosis and once Protamine was given. At the last TTFM the following values were detected: LIMA-LAD flow (Q) 15cc/min; Pulsatility Index (PI) 2.9; Diastolic Filling (DF) 73%; Acoustic Coupling Index 93%; SVG-D1 Q 10cc/min; PI 5.3; DF 57%; ACI 100% (Figure 2).
Air embolism in OPCAB represents a rare, but dreaded complication. Fluid-dynamics and solubility of gases in blood is complex. Gases dissolve in blood according to a number of variables (concentration, saturation, pressure, temperature and solubility) and to specific laws (Henry’s law). Every gas in contact with blood exists in an equilibrium between dissolved fraction and gaseous fraction. As far as the latter is concerned, the surface tension between gas and blood determines the diameter of the bubble / emboli. The greater the dimensions of the emboli are, the greater the chances to lodge in the body with a variety of consequences, most of which place the patient at some level of risk [1]. Gases rise in blood against the gravity vector, owing to their lower density. The highest points that gas (air) can reach in the circulatory system vary depending on several factors, like patient’s position, centrifugal direction of blood flow and pressure gradients. Since carbon dioxide (CO₂) dissolves in blood ≥25 times faster than air, CO₂ has been introduced in OPCAB for optimal visualization of the anastomosis with even lower risk of embolism. Although several non-standardized techniques have been developed to assist the CO₂ trapped within the heart to escape, de-airing maneuvers cannot totally prevent emboli, therefore early recognition is of great relevance in order to prevent considerable morbidity and mortality [2,3]. CO₂ insufflation in the circulatory system may be responsible for massive embolism, that may result in severe consequences such as neurological disorders, myocardial dysfunction and even death [3].

In our reported case two mechanisms occurred: trapped air (CO₂) and CO₂ embolism. The temporary sequence of the reported events does not allow any definitive conclusion on the pathophysiology of what happened, but allows us to do few considerations. First. Iatrogenic coronary air embolism during coronary angiography has an incidence of 0.1% to 0.3% [4]. Air emboli might be introduced to the coronary arteries along with the contrast injection [5]. In our case air embolism did not occur during catheterization, as no trace of air was visible in the diagnostic catheters and as signs of ischemia were already found on ICU. Second. Several mechanisms of embolism have been reported, frequently in association with major complications [2,6,7]. In our case, air remained long “silent”, most likely trapped by a prominent valve in the vein graft, preventing its detection. No sign of myocardial ischemia was found at the time of operation, Third. Although the surgical blower-mister device represents the most likely source of potential emboli, the origin of gaseous emboli remains speculative. Forth. Gaseous bubbles can temporarily prevent graft flow. In case of air blockage Transit Time Flow Measurement (TTFM) can show a suboptimal or no flow in the graft, while it allows to detect air bubbles by epicardial ultrasonography, preventing unnecessary graft revision [8]. According to the European Guidelines, graft evaluation is suggested before leaving the operating theatre (class I; level of evidence C) with recommended TTFM target values [9,10]. In our case air embolism did not occur during catheterization, as no trace of air was visible in the diagnostic catheters and as signs of ischemia were already found on ICU. Second. Several mechanisms of embolism have been reported, frequently in association with major complications [2,6,7]. 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remains extremely variable. Whether symptomatic or not, air embolism should be always ruled out, as a possible cause of graft dysfunction, before graft revision. Epicardial Ultrasound imaging adds a value to TTFM, since it allows to detect specific graft issues, such as air embolism. Therefore TTFM could ensure high quality of anastomosis in OPCAB surgery [11,12].

Conflict of Interest

The authors acknowledge no conflict of interest in the submission.

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