Title: Early Implementation of Veno-Venous Hemofiltration and Use of Rotational Atherectomy in a Patient with ST-Elevation Myocardial Infarction Complicated by Cardiogenic Shock- case report.

Short title: Rotational Atherectomy and CVVH in STEMI-CS

Key Clinical Message:

This case demonstrates that RA can be a safe option for STEMI patients in cardiogenic shock if extreme precautions like using small burr sizes and low speeds are used. CVVH may be the first-choice option in patients otherwise treated with Right Ventricular Mechanical Circulatory Support.

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Key words:

rotational atherectomy, myocardial infarction, cardiogenic shock, veno-venous hemofiltration, percutaneous angioplasty, case report

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Word count: 1199

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Abstract:

Background: We report the case of a patient with cardiogenic shock (CS) in a course of acute right ventricular (RV) myocardial infarction (MI) following occlusion of the proximal right coronary artery (RCA). Our case highlights the use of continuous veno-venous hemofiltration (CVVH) as a novel routine treatment option for acute kidney injury (AKI) in the setting of CS and the use of rotational atherectomy (RA) in patients with MI. This finding has important implications for patient treatment plans in the future.

Case summary: The patient was treated with the primary percutaneous coronary intervention (PCI) using three drug-eluting stents in the main RCA and strong right ventricular branch. RA was used to facilitate lesion expansion and stent implantation because of massive calcification. Six hours after the procedure, AKI manifested as anuria, required CVVH for four days until hemodynamic stabilization and restoration of diuresis. Six weeks after MI, the patient underwent coronary artery bypass surgery due to advanced coronary disease in the left coronary artery. There were no peri- or post-procedural complications, and at the end of a cardiac rehabilitation program, the patient was discharged.

Conclusion:

RA of calcifications in the infarct-related artery may remain the only option for delivering a stent, and thus maintain patency of the supplied coronary vessel, which is essential for hemodynamically unstable patients. RA can be a safe option if extreme precautions like using small burr sizes and low speeds are used. CVVH may be the first-choice option in patients otherwise treated with RV mechanical circulatory support.

Text:

Introduction:

Rotational atherectomy (RA) is currently used for calcified lesions that cannot be crossed by a balloon catheter or are so severe that a stent cannot be delivered to the target location. However, in the context of ST-segment elevation myocardial infarction (STEMI), RA is not routinely used during primary percutaneous coronary intervention (PCI) due to the risk of embolization caused by thrombus fragmentation. Prognosis of STEMI for cardiogenic shock (CS) depends on PCI effectiveness and pre-renal acute kidney injury (AKI) [1]. The role of continuous renal replacement therapy (RRT) in the treatment of CS after PCI has not been described. This case highlights the use of continuous veno-venous hemofiltration (CVVH) as a treatment option for acute renal failure.

Case Presentation:

A 61-year-old man with hypertension and hyperlipidemia presented to the emergency department after 8 hours of chest pain and an episode of syncope. His blood pressure (BP) was 80/66 mmHg and arterial oxygen saturation was 80%. An electrocardiogram showed complete atrioventricular blockage with a minimum heart rate of 31 beats/min (Figures 1, 2). An echocardiogram revealed distension and hypokinesis of the right ventricle (RV), hypokinesis of the inferior wall, and a left ventricular ejection fraction (LVEF) of 50% (Figure 3, Movie 1). A temporary pacing wire was inserted into the apex of the RV. The patient was loaded with oral aspirin (300 mg) and ticagrelor (180 mg). Perioperatively, we used heparin with an activated clotting time >250 sec. Coronary angiography revealed significant proximal left main coronary artery stenosis at the level of the aorto-ostial junction, a tight lesion in the proximal to mid-segment of the left anterior descending artery extending into the vessel bifurcation causing a 50–60% diameter stenosis of the large diagonal branch, and a critical ostial lesion of the left circumflex artery (Movies 2, 3, and 4). Occlusion of the proximal segment of the right coronary artery (RCA) (Movie 5) caused the patient's MI. The occlusion was crossed using a Judkins Right 4 (JR4.0/6F) guiding catheter (Medtronic) and a Whisper ES wire (Abbott). The RCA was predilated sequentially with semi-compliant

2.0/15 mm and non-compliant (NC) 2.5/20 mm balloons (Movie 6), but lesion expansion was inadequate, and we changed to an Amplatz left (AL1.0/6F) guiding catheter (Medtronic). Low-speed rotablation (140.000 rotations per minute (rpm)) was performed in three passages using a 1.25-mm burr with an extra-support Rota-wire (BSC, USA), (Movie 7). Attempts to fully expand a 3.0/20 mm NC balloon were unsuccessful (Movie 8). Subsequent rotablation with a 1.75 mm burr (Movie 9) was followed by expansion of a 3.5/15 mm NC balloon. A 3.5/38 mm Resolute Integrity zotarolimus-eluting stent (Medtronic) was deployed at the distal/mid-RCA, (Movie 10). Due to lack of peripheral flow in the large right ventricular branch (RVB), the Whisper ES guidewire was run through the stent cell to the RVB, which was stented with a 2.5/38 mm Resolute Integrity stent using the T and small protrusion technique (Movie 11). Due to ostial RCA dissection, along with dissection of the right coronary sinus of Valsalva, the 3.5/38 mm Resolute Integrity stent was implanted to cover the RCA ostium, with a 4.0/38 mm Resolute Integrity stent overlapping distally (Movie 12). A 4.0/15 mm NC balloon was used to post-dilate the stents and establish a thrombolysis in myocardial infarction (TIMI) grade 2/3 flow in the RCA and a TIMI 2 in the RVB, with a residual, stable contrast staining in the aortic wall (Movies 13,14). Due to the sinus of Valsalva dissection, we did not administer antiplatelet therapy using a IIb/IIIa blocker. The amount of contrast you used during the procedure was 400 ml. Hemodynamic parameters improved immediately after PCI (BP-110/70 mmHg). However, continuous infusion of inotropes and vasopressors (norepinephrine, dobutamine) were required for 24 hours to maintain a mean arterial pressure of 60-65 mmHg. The A-V block resolved immediately after the procedure. Several hours later, the patient became anuric, and the potassium and lactate levels increased, indicating CVVH implementation. The patient's general condition improved after 24 hours. On the third day post-admission, diuresis, forced by continuous furosemide infusion, returned and CVVH was stopped the next day. Noradrenaline was discontinued on the second and dobutamine on the fifth day in the cardiology intensive care unit (CICU). High-sensitivity troponin T levels were measured on admission to the CICU and 24 hours following the onset of chest pain, yielding values of 3,120 ng/mL and 30,510 ng/mL, respectively. The patient's creatinine level on hospital admission was 99 μmol/L; the maximum value was 106 μmol/L. An echocardiogram 36 hours post-procedure showed improvement in RV size and global function (Movies 15,16). Due to significant stenosis in the left coronary artery, the patient underwent coronary artery bypass grafting six weeks after the MI. He did not report any complications at the 6-month follow-up.

Discussion:

We present the case of a patient with STEMI in CS for whom RA allowed delivery of a stent to the infarct-related artery (IRA), leading to a successful procedure and patient survival. To minimize the no-reflow risk, we used a small burr size (1.25 mm), a short burr time (10-15 sec), and a low rotation speed (140,000 rpm). However, the 1.25-mm burr was ineffective, and inadequate lesion expansion with a 2.5 NC balloon was observed. Using a 1.75-mm burr allowed for adequate dilatation with a 3.0 NC balloon followed by stent implantation. Use of RA in STEMI is described in only one published case regarding CS [2]. Previous work demonstrated successful RA in 10 cases of acute MI when standard balloon angioplasty failed. The paramount risk factor for no-reflow was calcified lesion length, while presence of MI was irrelevant [3]. Additionally, RA has been successfully used in 23 patients with severe left ventricular (LV) dysfunction. If a stent cannot be delivered, RA appears effective and safe for high-risk patients with significantly impaired LV-systolic function [4]. Indications for RRT include hyperkalemia and severe acidosis secondary to anuria, despite fluid resuscitation and intravenous diuretic treatment. Mortality for RV-CS patients is similar to that of LV-CS patients [5]. Furthermore, the occurrence of oliguria during the first 24 hours of CS worsens prognosis for these patients [1]. Prevention of AKI through early CVVH may improve the prognosis of patients with CS during acute MI [6][7]. Clinical use of RRT, including appropriate treatment indications and initiation and discontinuation timing, remains poorly defined. Using CVVH in our patient with acute RV failure-caused CS was effective in removing venous congestion (backward failure) and excess fluids. To our knowledge, using early RRT in the setting of CS treated with PCI has only been described by Marensi et al. [7] Temporary RV mechanical circulatory support is preferred for treatment of CS caused by RV failure, and 75% of patients treated thusly fully recover [8]. However, because of major bleeding in nearly 25% of this group [9], we decided to use CVVH first. Hemodynamic stabilization and diuresis restoration secondary to gradual improvement of RV function was likely associated with successful revascularization of the RVB [10].

RA of massive calcifications in the context of STEMI may remain the only option for stent delivery to the IRA, which is important for hemodynamically unstable patients. This case highlights the use of CVVH as a supportive therapy for AKI caused by RV infarction complicated by CS. CVVH may be the preferred first alternative treatment in patients otherwise treated with RV mechanical circulatory support.

Acknowledgments: N/A

Conflict of Interest: N/A

Author's Contribution:

1. **Monika Durak** – corresponding author – collected and assembled of data, drafted the manuscript, performed index procedure.
2. **Marek Tomala** - revised the manuscript for intellectual content, performed index procedure, physician treating cardiogenic shock and renal failure.
3. **Bartłomiej Adam Nawrotek** - revised the manuscript for intellectual content, physician treating cardiogenic shock and renal failure.
4. **Jacek Legutko** - reviewed and approved the final manuscript.

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Figure Legend:

Fig.1, 2

Electrocardiogram recorded on admission demonstrated complete AV block, and acute myocardial infarction with ST segment elevation in inferior leads (II, III and aVF). Reciprocal ST-segment depression V1-V6.

Fig.3

Transthoracic echocardiogram on admission:

RV modified apical 4-chamber view revealed enlargement of the RV at end-diastole with maximum diameter = 47.3 mm at the base level.

Movie Legend:

1. Movie 1: Transthoracic echocardiogram on admission RV modified apical 4-chamber view: distension and extensive hypokinesis of the right ventricle (RV) with hypokinesis of the inferior wall and a left ventricular ejection fraction (LVEF) of 50%.
2. Movie 2: the RAO (right anterior oblique) caudal view, Movie 3: the AP (anterior-posterior) cranial view, Movie 4: the LAO (left anterior oblique) view:
   significant proximal left main coronary artery stenosis at the level of the aorto-ostial junction, tight lesion in the proximal to mid-segment of the left anterior descending artery (LAD) extending into the vessel bifurcation causing a 50–60% diameter stenosis of the large diagonal branch critical ostial lesion of the left circumflex (LCX) artery.
3. Movie 5: the LAO (left anterior oblique) view
   Coronary angiography showing complete occlusion of the proximal segment of the right coronary artery (RCA). Temporary pacemaker wire can also be seen.
4. Movie 6: the LAO (left anterior oblique) view
   Coronary angiography showing inadequately expanded NC 2.5 x 20 mm balloon with Judkins right 4.0/6F guiding catheter in the proximal portion of RCA.
   Movie 7: the LAO (left anterior oblique) view
   Coronary angiography showing RCA rotablation using 1.25 burr crossing the lesion with a Rota-wire extra support in situ at 140.000 rpm. An Amplatz 1.0 left guiding catheter was used.
5. Movie 8: the LAO (left anterior oblique) view
   Coronary angiography showing unsuccessful NC 3.0 x 20 mm - balloon dilatation caused by a no dilatable calcified lesion.
6. Movie 9: the LAO (left anterior oblique) view
   Coronary angiography showing RCA rotablation using 1.75 burr at 140.000 rpm
7. Movie 10: the LAO (left anterior oblique) view
   Coronary angiography showing Resolute Integrity 3.5 x 38 mm stent implantation in distal/mid RCA.

8. Movie 11: the RAO (right anterior oblique) view

   Coronary angiography showing Resolute Integrity 2.5 x 38 mm stent implantation in the large right ventricular branch using the T and small protrusion technique.

9. Movie 12: the LAO (left anterior oblique) view

   Coronary angiography showing dissection of the right coronary sinus of Valsalva. Overlapping deployment of Resolute Integrity 4.0 x 38 mm stent covering the RCA ostium.

10. Movie 13: the LAO (left anterior oblique) view, Movie 14: the RAO (right anterior oblique) view.

    Final angiographic result at the end of procedure. Stable contrast staining in the aortic wall.

11. Movies 15, 16: Transthoracic echocardiogram 36 h after procedure; parasternal long axis view and apical four chamber view. Significant improvement in RV size and global function.