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Diagnosis of coronary affection in patients with AADA and treatment of postcardiotomy myocardial failure using extracorporeal life support (ECLS)

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ABSTRACT

Background: Myocardial ischemia due to concomitant coronary artery disease (CAD) or coronary dissection in patients with acute aortic dissection type Stanford A (AADA) is associated with myocardial failure and poor outcomes. Preoperative coronary angiography in this group of patients is still debated. The use of CT scan to diagnose coronary affection along with the establishment of high-pitched dual-spiral CT protocols are essential for improving outcomes.

Methods: We retrospectively analyzed six AADA patients with heart failure who were treated using extracorporeal life support (ECLS). Options for diagnosing coronary affection and different therapeutic strategies for postcardiotomy cardiogenic shock in this patient cohort are discussed.

Results: Retrospective review of CT images showed coronary abnormalities in 83% (n = 5). Four patients (67%) underwent unplanned coronary artery bypass grafting (CABG). ECLS was instituted in 67% (n = 4) due to left heart failure and in 33% (n = 2) due to right heart failure. Thirty day mortality was 67% (n = 4). The two patients that received ECLS for right ventricular support survived and both had undergone CABG.

Conclusion: Besides preoperative evaluation of the extent of the dissection, focus on coronary affection in CT-scans helps to triage the operative procedure. Hybrid operating rooms allow for immediate interventional and/or surgical treatment and enable for immediate control of revascularization results. The use of ECLS over other types of ventricular support systems may allow for myocardial recovery in selected cases.

INTRODUCTION

Acute chest pain is the cardinal symptom in the majority of patients suffering from acute aortic dissection type Stanford A (AADA). Myocardial ischemia due to concomitant coronary artery disease (CAD) or coronary artery dissection is associated with myocardial failure and poor outcome after AADA repair, especially if the left territory is involved [Lentini 2011; Imoto 2013].

For patients with acute chest pain, the use of high-pitched dual-spiral cardiothoracic computed tomography using second generation dual source computed tomography systems allows for diagnosis of pulmonary embolism, AADA and CAD (triple rule out). It can also detect concomitant CAD or coronary dissection secondary to AADA [Bamberg 2012]. Modern hybrid operating rooms allow for additional preoperative coronary diagnostics in patients with AADA, as well as postoperative control if necessary.

In cases of postoperative low cardiac output syndrome (LCOS) due to myocardial ischemia, different treatment strategies exist. Extracorporeal life support (ECLS) for postcardiotomy myocardial failure is a well established option [Beckmann 2011]. However, less favorable outcomes were seen in patients with severe myocardial damage, and little data exist for ECLS use in AADA patients [Doguet 2010; Rastan 2010]. Intra-aortic balloon counterpulsation (IABP) did not improve early or one year survival in cardiogenic shock patients [Thiele 2012; Thiele 2013]. The use of IABP in AADA patients is relatively contraindicated, therefore only limited reports of this exist [Jaussaud 2013]. The use of micro axial pumps and direct implantation via a vascular graft sewn to the aorta is an established method for postcardiotomy support; however, no data exist for use of this technology in AADA patients [Griffith 2013]. Here we present a case series of patients with LCOS after AADA repair and discuss the technical possibilities for diagnosing coronary affection and controlling LCOS.

METHODS

From January of 2010 to September of 2013, 177 patients were operated on due to AADA. In six patients (3%) ECLS was instituted due to failure to wean from cardiopulmonary bypass (CPB) as a result of LCOS. We retrospectively reviewed CT scan images looking for CAD or coronary artery dissection as the potential underlying cause of myocardial impairment. CT scans were performed on a second generation dual-source computed tomography system (Siemens Somatom Definition Flash, Siemens Medical Solution, Forchheim, Germany). The comprehensive cardiothoracic high-pitched protocol was performed using tube voltages of

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Demographic and peri-operative data.

No	m/f	Age	Root dissected	Arch dissected	AR	Coronary findings (CT-scan)	Root repair/ replacement	HCA	CABG	Heart failure
1	m	70	+	+	-	left main dissection	-	+	+	biventricular/left
2	m	81	-	+	+	coronary artery sclerosis (LAD plaque)	-	+	-	left
3	f	77	+	+	+	coronary artery dissection and sclerosis (LAD plaque)	+	+	-	biventricular/left
4	m	64	-	+	-	left main stenosis	-	+	+	left
5	f	29	-	+	-	none	-	+	+	biventricular/right
6	f	65	+	+	+	2-vessel disease and coronary artery sclerosis	+	+	+	biventricular/right

Pt/patient number, male/female, RD/root dissected, AD/arch dissected, AR/aortic regurgitation, CT scan/ coronary findings, RR/root repair/replacement, access, ECLS/VA venous access, Cardioplegia/Bretschneider solution (mL), ECLS support (hours), Death/ on post-op day #.

2x 100 kV (BMI 30) and a 370 mAs tube current. Within a single breath hold, image acquisition was obtained in a cranio-caudal direction. Typically, 90 mL of contrast agent was used at 6 mL/s. Acquisition was initiated 5s after initial opacification of the ascending aorta. Unfortunately, in these patients no further evaluation of the coronary arteries was performed after the diagnosis of AADA was made.

For ECLS support, Stöckert SCP Systems (Sorin group, Munich, Germany) was used.

Due the limited number of patients, only descriptive statistics was used. The study was approved by the institutional ethics committee.

RESULTS

Demographic and peri-operative data are depicted in the table. Three patients were female (50%) and mean age was 64 ± 19 years. Four patients (67%) had received unplanned coronary artery bypass grafting (CABG). Patient 1 received a venous bypass graft to the circumflex artery due to left ventricular failure. Patient 4 received a saphenous graft to the left anterior descending and the first diagonal branch and another graft to the circumflex artery, due to left ventricular failure within a second phase of cross clamping. In Patient 5, bypass grafting to the right coronary artery due to suspected coronary dissection was performed during reperfusion and another bypass to the left anterior descending was performed secondarily off-pump due to suspected dissection of the left main coronary artery. Patient 6 received right coronary artery bypass grafting due to calcification and dissection of the vessel while on bypass.

Retrospective review of CT scan images revealed coronary artery sclerosis in three cases (50%); two patients (33%) presented with manifest CAD. Dissection of the coronary arteries was seen in two patients (33%). Altogether, 83% (n = 5) showed abnormalities of the coronary vessels (Figure).

ECLS was instituted in four cases (67%) due to a compromised left ventricle and in two cases (33%) due to a compromised right ventricle. Thirty day mortality was 67% (n = 4). All patients died of multi-organ failure secondary to fulminant myocardial damage. Both patients that received ECLS for right ventricular support survived and had undergone CABGs. Mean CPB time and cross-clamp times were longer in patients that survived (306 ± 3 min versus 212 ± 47 min, 172 ± 11 min versus 101 ± 36 min, respectively). Peak levels of creatine kinase (CK), CK MB-isoenzyme levels (CK-MB) and troponin were 5259 ± 3863 U/L, 724±557 U/L and 339 ± 119 ng/mL in patients that died and 964±100 U/L, 57 ± 11 U/L and 75 ± 35 ng/mL in patients that survived, respectively.

At six month follow-up, patient 5 was in good condition and patient 6 in excellent general condition. This patient initially presented with neurological symptoms and suffered from hemiparesis post-operatively. At follow-up only a mild residual paresis of the left arm persisted.

DISCUSSION

ECLS is often used as bail out for postcardiotomy syndromes or cardiogenic shock if stabilization is not feasible otherwise [Rastan 2010; Beckmann 2011; Guenther 2014]. However, data for ECLS use in AADA are nearly non-existent

CPB - arterial access	CPB - venous access	CPB time (min)	Cross-clamp time (min)	ECLS - arterial access	ECLS - venous access	Cardioplegia (Bretschneider solution, mL)	ECLS support (h)	Death on post-op day
aorta/ prothesis	right atrium	233	119	prothesis	femoral	1300	16	1
brachio-cephal-ic trunk via prosthesis	right atrium	182	84	brachio-ce-phalic trunc via prothesis	right atrium	1200	42	2
femoral	femoral	165	60	femoral	femoral	1500	3	0
femoral/ prothesis	femoral	267	140	prothesis	right atrium	1500	6	1
aorta/ prothesis	right atrium	308	180	prothesis	right atrium	2100	84	survived
femoral/ prothesis	right atrium	304	164	prothesis	right atrium	1500	103	survived

HCA/ hypothermic circulatory arrest, HF/ heart failure, CPB/AA arterial access, CPB/VA venous access , CC cross-clamp time (min), ECLS/AA arterial

[Doguet 2010]. This may be due to the fact that, especially if cannulation of the femoral vessels is performed, retrograde dissection from a second entry tear may occur. In addition, perfusion of only one lumen resulting in malperfusion is a risk. In our case series, cannulation of the side branch of the arch prosthesis was performed in four of the patients, which is a feasible option to establish antegrade blood flow and thus reduce the risk of malperfusion and prevent retrograde dissection.

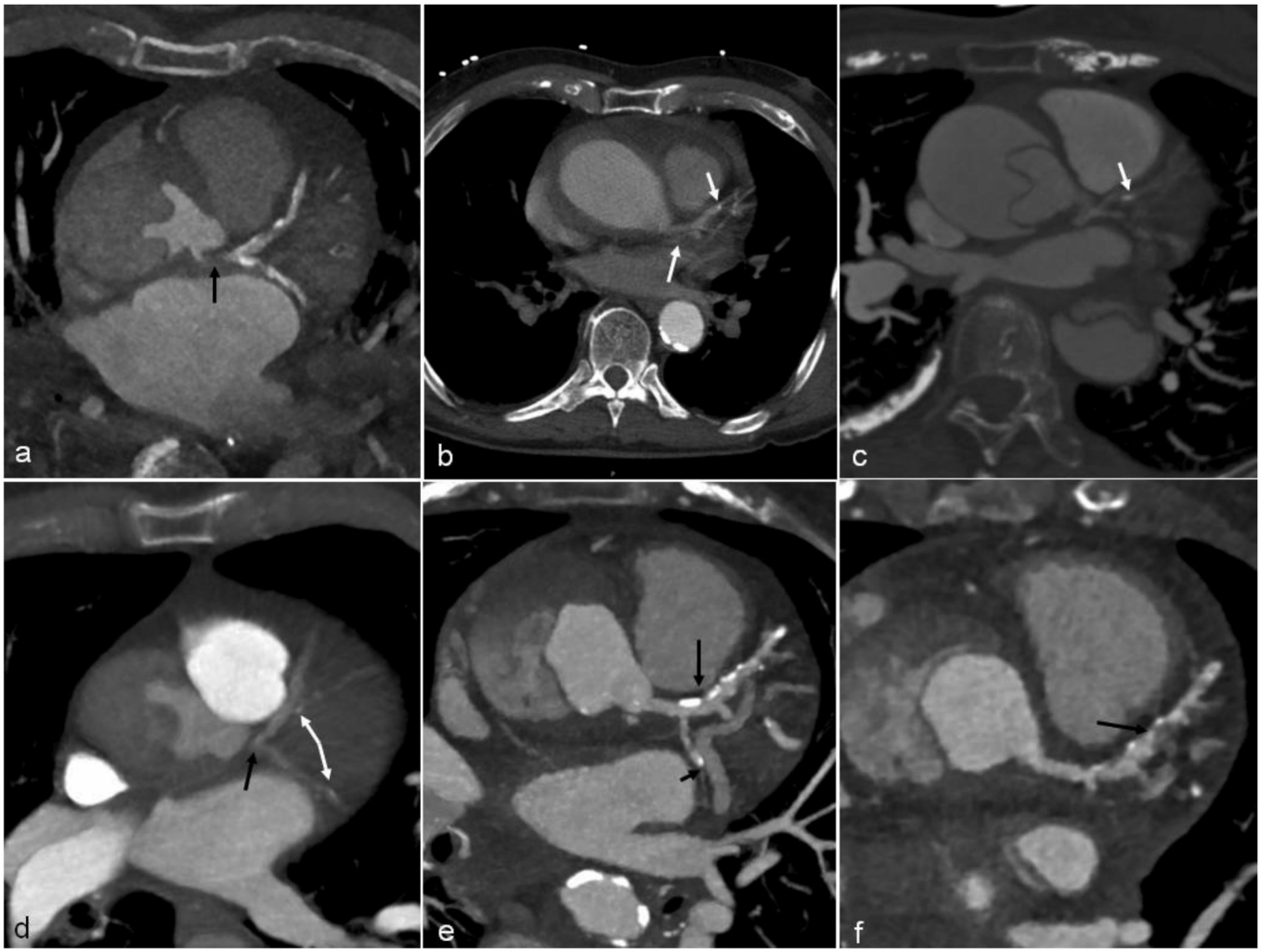
Alternatively, the use of either IABP (Maquet Cardiac Assist, Rastatt, Germany) or micro axial pumps (Abiomed Europe, Aachen, Germany) are options [Griffith 2013; Jaussaud 2013]. Both can be implanted via the femoral artery, or alternatively, via a graft to the aorta. The side branch of the ascending aortic prosthesis (Vascutek, Hamburg, Germany) can also be used. It is unclear if ventricular unloading can be achieved by balloon counterpulsation in patients with a dissected or enlarged aorta. However, in various clinical as well as experimental observations, ECLS therapy leads to better LV function and improved survival [Peterss 2014; Sattler 2014]. Axial pumps achieve flow rates of up to 5 liters and ensure direct unloading of the left ventricle. In the case of right ventricular failure, so far no commercially available options for axial pumps exist. Neither IABP nor axial pumps offer options for additional lung support. Acute respiratory dysfunction after AADA repair is a common problem [Girdauskas 2010]. Up to 13% of these patients suffer from respiratory failure, especially patients with preoperative malperfusion. With the arterial cannula positioned within the aortic arch, ECLS provides additional lung support and avoids upper body hypoxemia.

Myocardial ischemia secondary to AADA or due to concomitant CAD increases morbidity and mortality. In our case series, all except one patient showed coronary abnormalities. Using CT imaging for detecting signs of coronary artery affection and establishing high-pitched dual-spiral cardiothoracic CT protocols might help to improve outcomes in this group of patients [Bamberg 2012].

The use of preoperative coronary angiography in patients with acute type A aortic dissection is still debated [Motallebzadeh 2004]. In a recent report, preoperative stenting of dissected coronary arteries was associated with a reduced incidence of LCOS [Imoto 2013]. However, delayed surgery increases the risk of aortic rupture and the number deaths during the procedure is unknown. Further issues are stent thrombosis, perioperative antiplatelet therapy, and the difficulty of placing the guide wire into the true lumen. No data for pre-operative stenting of CAD exist in AADA patients.

In cases of suspected CAD, coronary artery bypass grafting is recommended. Restoration of coronary blood flow is crucial in cases of coronary dissection [Imoto 2013]. It remains unclear whether ischemic regions due to coronary dissection can be sufficiently revascularized, or if revascularization prevents further infarction [Westaby 2013]. In our case series both patients that survived underwent unplanned CABG.

Both of our patients that underwent ECLS for right ventricular support survived; the remaining four patients who had suffered from a mainly compromised left ventricle died. This is in line with the results of other authors [Imoto 2013]. In selected cases of right heart failure, ECLS might thus serve



Examination of the patients was performed using a second generation dual-source computed tomography system (Siemens Somatom Definition Flash, Siemens Medical Solution, Forchheim, Germany). The detailes protocol has been decribed previously [Bamberg 2012]. A, Patient 1: Left main coronary artery dissection with resulting high-grade stenosis. Calcified and non-calcified plaques in the left anterior descending and left circumflex artery. B, Patient 2: Intramural hematoma of the ascending aorta and calcified plaque of the left anterior descending coronary artery (arrow). No stenosing coronary artery disease. C, Patient 3: Calcified plaque of the left anterior descending coronary artery (arrow). No stenosing coronary artery disease. D, Patient 4: Left main coronary artery stenosis (black arrow) and calcified plaques in the left anterior descending and left circumflex artery (white arrows). E, Patient 5: Maximum-intensity-projection (MIP)-reconstruction showing calcified plaques in the proximal and middle part of the left anterior descending artery (long arrow) and obstruction of the proximal left circumflex artery (short arrow). F, Same patient. Large non-calcified plaque of the left anterior descending artery.

as a therapeutic bridge allowing for myocardial recovery. However, these results as yet have to be proven statistically in larger patient cohorts.

The hybrid operating room can provide additional preoperative coronary diagnostics in patients with AADA and postoperative control if necessary. It might be a feasible alternative to the standard setup [Tsagakis 2013]. Simultaneous hemodynamic control, non-invasive and invasive diagnostics and immediate surgical and/or interventional treatment are possible in this scenario. Furthermore, postoperative quality control can be performed if signs of coronary malperfusion occur [Shrestha 2008].

CONCLUSION

A diagnosis of AADA can distract from evaluation of the patient for concomitant morbidity, as demonstrated in this case series. Preoperative CT scan for detecting coronary affection and for evaluation of the extent of dissection helps to triage the operative procedure. Performing CABG in suspected or confirmed cases of coronary artery affection is crucial. In cases of right ventricular failure, ECLS might serve as a temporary assist device. The indications for ECLS should be based on the pre- and intra-operative status of the patient on an individual case-by-case basis. If ECLS is indicated,

antegrade arterial access should be established. In cases of left heart failure, ECLS therapy has not been shown to be effective, presumably due to the severity of myocardial damage. It remains questionable whether the use of other devices discussed above can improve the outcome in this high risk patient cohort. Hybrid operating rooms with the advantage of immediate diagnostic and therapeutic options might further improve patient outcomes.

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