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Research article

The outcome of acute occlusion of the abdominal aorta with bilateral limb ischaemia

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ABSTRACT

Background: The purpose of this study was to investigate if the duration of bilateral acute limb ischaemia (BALI) caused by acute aortic occlusion (AAO) affected amputation-free survival.
Materials and methods: A retrospective analysis of patients treated between 1 January 2010 and 1 January 2019 for primary occlusion of the infrarenal aorta and BALI was performed. Univariate analysis was used to determine the risk factors for adverse outcomes and compare the duration of BALI between the amputation-free survival and non-amputation-free survival groups.
Results: The data from 16 patients with a mean age of 70 ± 11 years were analysed. Predominantly females (56.3%, 9/16) were included in the study. Out of 16 patients, nine had Rutherford grade IIb, and seven had Rutherford grade III at admission. Seven patients underwent revascularisation attempts, two underwent primary major amputation, and seven underwent primary palliation. The mean ischaemia time was significantly shorter in the amputation-free survival group than in the non-amputation-free survival group (7.4 ± 3.5 h vs 22.4 ± 16.3 h, $p = .01$). The time frame for successful bilateral lower limb revascularisation was <11 h ($p = .03$).
Conclusions: The duration of BALI due to AAO of <11 h was shown to be associated with improved amputation-free survival.

1. Introduction

Bilateral acute limb ischaemia (BALI) caused by acute aortic occlusion (AAO) is a rare but life-threatening condition associated with high mortality and amputation rates [1, 2, 3, 4]. Despite a slight improvement over the past decade, treatment outcomes have remained poor [4]. Current guidelines recommend emergent revascularisation of acute limb ischaemia (ALI) secondary to AAO to improve outcomes [5].

Previously published series have analysed heterogeneous cohorts of patients with AAO. However, they have failed to determine the time frame for successful revascularisation, which may be crucial for aligning prehospital care protocols and routing patients to high-volume centres, thereby improving outcomes [1, 6, 7].

Although the recognised optimal revascularisation time is 4–6 h, improved amputation and survival rates have been reported for unilateral ALI with ischaemia lasting up to 12–24 h [8, 9, 10]. The time frame for successful revascularisation of BALI may vary due to the fact that large muscle mass ischaemia due to AAO, reduced collateralisation, and severe multiorgan failure after reperfusion are all factors to consider.

The goal of this study was to determine the optimal time frame for successful bilateral lower limb revascularisation and the effect of BALI duration due to AAO on amputation-free survival.

2. Materials and methods

2.1. Study design

A retrospective, single-centre analysis of clinical data of patients with BALI admitted between 1 January 2010 and 1 January 2019 was performed. The clinical and anamnestic data were retrieved from the patients' medical records.

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2.2. Study population

This study included patients with BALI due to primary acute occlusion of the infrarenal aorta. Patients with unilateral ALI, suprarenal aortic occlusion, bilateral occlusion of aortobifemoral grafts, or multiple acute simultaneous arterial occlusions of the upper and lower extremities were excluded (Figure 1). All patients with unknown symptom onset times and/or thrombophilia were also excluded.

2.3. Treatment protocol

The diagnostics were performed on an outpatient basis, and the patients were transported to the treatment site. The transport distance was 40–200 km. All ALI patients with Rutherford grade IIb were scheduled for revascularisation. Palliation was chosen for critically ill patients with uncontrolled hypotension and extended bilateral buttock, thigh, and calf rigours. Primary thigh amputation with blood flow restoration in the deep femoral artery was scheduled in cases of calf rigour.

After admission, all patients received full heparinisation with a 100 IU/kg intravenous bolus, followed by a supporting dose of 1000 IU/hour under the control of the partial thromboplastin time (PTT). The therapeutic level of PTT was estimated to be 60–70 s.

To estimate the level and extent of occlusion preoperatively, duplex ultrasound and/or contrast-enhanced spiral computed tomography angiography of the entire aorta with a slice thickness of 1 mm were performed (Figure 2).

All procedures were performed by certified vascular surgeons. Using the standard transfemoral approach and the Fogarty balloon catheter, the revascularisation procedure was performed as an aortic thrombectomy. Intraoperative balloon catheter-mediated revision of the distal run-off was obligatory. After revascularisation, all patients underwent bilateral four-compartment calf fasciotomy with subsequent secondary wound closure.

Postoperatively, full intravenous heparin anticoagulation was administered in the hospital under PTT monitoring. After discharge, lifelong anticoagulation with oral anticoagulants was recommended.

2.4. Follow-up

The standard FU protocol included clinical and sonographic examinations before discharge and annually thereafter. All sonographic series were assessed by an independent radiology collaborator. The FU examinations were performed by vascular surgeons.

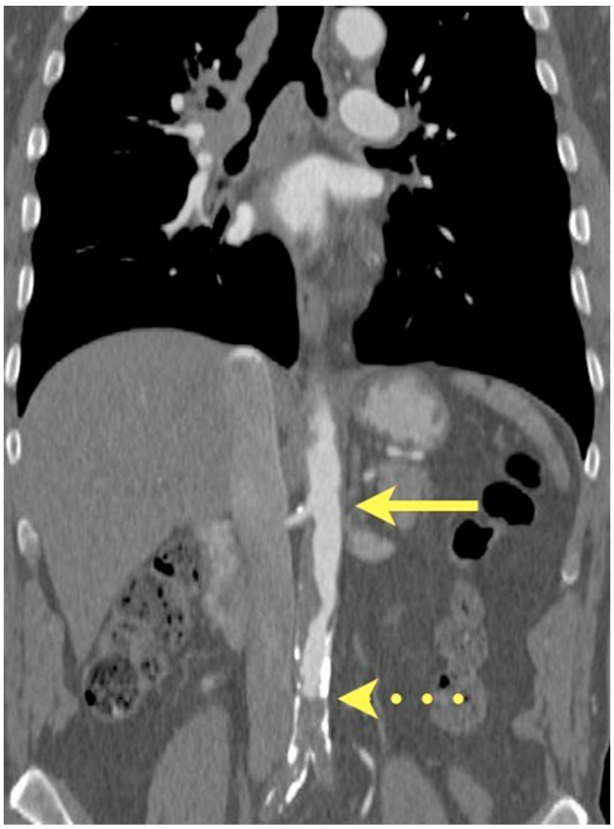

Figure 2. CTA. Level of thrombotic occlusion of terminal aorta. Arrow–right renal artery; dashed arrow–level of the occlusion.

All patients (100%, 5/5) who exhibited amputation-free survival within 30 days after revascularisation were followed until November 2020.

2.5. Definitions

Acute bilateral limb ischaemia was defined as the sudden onset of ischaemic symptoms in both lower extremities lasting less than 2 weeks

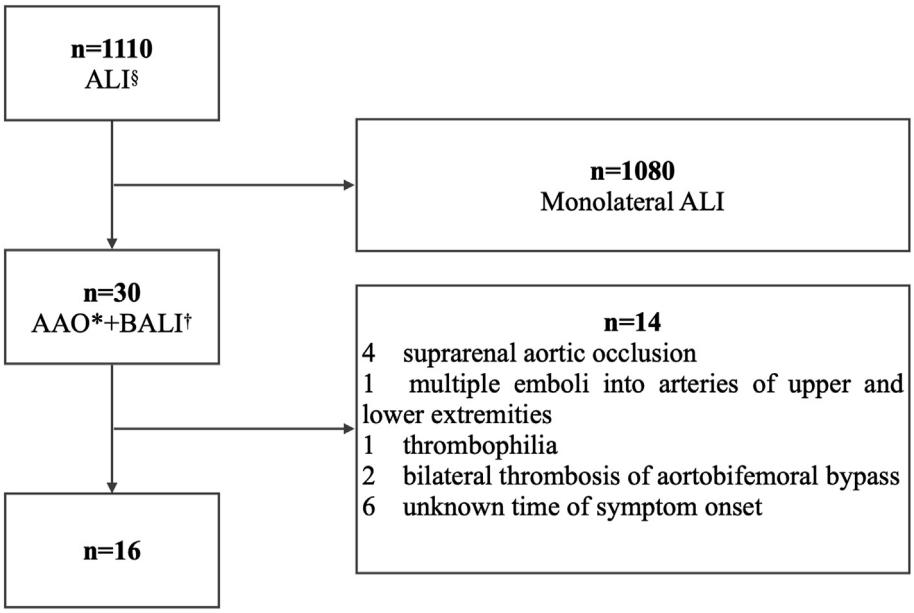

Figure 1. Flow-chart. ALI, Acute limb ischemia; AAO, acute aortic occlusion; BALI, bilateral limb ischemia.

[5]. The grade of acute bilateral lower extremity ischaemia was classified using international clinical and sonographic criteria [11].

Technical success was defined as the prompt restoration of antegrade arterial flow in a target vessel based on the absence of residual arterial stenosis >40% on the postoperative duplex examination.

Procedural success was defined as technical success without complications [11].

The duration of ischaemia was defined as the period between symptom onset and flow restoration (in the case of revascularisation) or until decision-making (in the case of palliation).

The definition of early-term FU (up to 30 days) and mid-term FU (1–5 years) was made according to current reporting standards [12].

Myocardial infarction (MI) was defined as myocardial necrosis accompanied by an increase and/or decrease in cardiac biomarker values (preferably cardiac troponin), clinical symptoms of ischaemia, new significant ST- and T-wave (ST-T) changes, and a new left bundle branch block or development of pathological Q waves on electrocardiogram [13].

2.6. Statistical analyses

Statistical analyses were performed using SPSS version 25.0 (SPSS, Inc., Chicago, IL, USA). Means and standard deviations (means ± SDs) were used to present continuous data. Categorical variables were presented as absolute numbers and percentages. A cross-tabulation analysis was performed to characterise the sample. Using the χ^2 test for categorical data and the Mann-Whitney U test for continuous data, a univariate analysis was conducted to identify differences between the groups being compared. The significance level for each statistical test was determined to be $p < .05$.

2.7. Statement of ethics

The authors declare that this study was performed in accordance with the World Medical Association's Declaration of Helsinki**.** All patients gave written informed consent for collection and processing of clinical data. An approval for the retrospective analysis of the prospectively cumulated clinical data was received from the local ethics committee of Krasnodar Regional Clinical Hospital #1 (protocol no.115-23/05/2019). The study was retrospectively registered in the TCTR international registry (identification no. TCTR20210609002, date of registration 09/06/2021).

3. Results

The study included a total of 16 patients, with a mean age of 70 ± 11 years and a female predominance (56.3%, 9/16). The majority of patients had arterial hypertension and coronary artery disease (68.8%, 11/16 and 62.5%, 10/16, respectively). According to the Rutherford classification, 56.3% (9/16) of patients had BALI grade II (Table 1). BALI due to embolisation was diagnosed in 62.5% (10/16) of cases. Atrial fibrillation (AF) was observed in 43.8% (7/16) of patients, and thrombogenic (shaggy) thoracic aorta was observed in 18.8% (3/16) of patients. Nearly a third of patients (31.2%, 5/16) were estimated to have a history of peripheral arterial disease (PAD). All the demographic data are presented in Table 1. There were no reports of malignancy or preoperative ambulatory anticoagulation. The mean duration of BALI was 17.7 ± 15.2 h.

Table 1. Demographic data[a].

Characteristics		Total n = 16% (n/N)
Gender	male	43.7 (7/16)
	female	56.3 (9/16)
Age, years		70 ± 11
Etiology	Emboli	62.5 (10/16)
	Thrombosis	37.5 (6/16)
Rutherford grade of ischemia	2b	56.3 (9/16)
	3	43.7 (7/16)
PAD		31.2 (5/16)
AF		43.8 (7/16)
Thrombogenic thoracic aorta		18.8 (3/16)
Congestive heart disease		43.7 (7/16)
Coronary heart disease		62.5 (10/16)
Arterial hypertension		68.8 (11/16)
Stroke		25.0 (4/16)
Hypercholesterinemia		43.7 (7/16)
CRI		18.7 (3/16)
Diabetes mellitus		37.5 (6/16)

PAD, peripheral arterial disease; *AF*, atrial fibrillation; *CRI*, chronic renal insufficiency.

[a] Categorical data are presented as absolute numbers and percentage; continuous data are presented in mean ± SD.

3.1. 30-day outcomes

Transfemoral thrombectomy was performed on 43.8% (7/16) of all patients who underwent surgery (56.3%, 9/16). The technical success rate for revascularisation was 100% (7/7), and the procedural success rate was 71.4% (5/7). Two patients experienced mortality following thrombectomy on the first postoperative day due to MI. Thus, the revascularisation group had a 28.6% mortality rate (2/7).

In 12.5% (2/16) of patients with calf rigour, thigh amputations of the lower extremities were performed unilaterally or bilaterally. A single lower limb amputation was performed on a patient with a BALI duration of 63.5 h. On postoperative day 24, this patient was discharged and experienced ambulatory mortality due to a pulmonary embolism. A second patient who underwent bilateral amputations after 37.5 h of BALI perished on the second postoperative day as a result of multiorgan failure.

Patients scheduled to receive palliative care accounted for 43.8% (7/16) of the sample size. In this group, in-hospital mortality reached 100% (7/7) due to multiorgan failure (85.7%, 6/7) and MI (14.3%, 1/7). The overall 30-day mortality rate was 62.5% (10/16). The amputation-free survival rate was 31.3% (5/16).

Univariate analysis of risk factors for amputation and mortality was performed after separating the patients into group A (amputation-free survivals) and group B (non-amputation-free survivals). The duration of ischaemia was significantly shorter in group A than in group B (7.4 ± 3.5 h vs 22.4 ± 16.3 h, $p = .01$) and an 11 h threshold was shown to be critical for limb amputation-free survival ($p = .03$) (Table 2). Revascularisation and a lower grade of BALI improved amputation-free survival ($p = .002$ and $p = .03$, respectively) (Table 2).

3.2. Mid-term outcomes

The FU ranged from 26 to 108 months, with a median of 32 months. All patients (100%, 5/5) who showed 30-day amputation-free survival were followed 24 months after revascularisation, and 80% (4/5) of patients were followed after 30 months. During the FU period, no mortality or vascular reinterventions were reported. One patient (20%, 1/5) underwent unilateral thigh amputation at FU month 53 due to worsening infrainguinal PAD and concomitant gangrene, despite aortoiliac arterial segment patency. Amputation-free survival remained persistent at FU months 24 and 32 (31.3%, 5/16) compared to the 30-day outcome.

4. Discussion

The consequences of ischaemia depend on both its duration and severity (Rutherford classification).

Table 2. Univariate analysis of risk factors for amputation-free survival[a].

Characteristics		Amputation-free survivals% (Total n = 5)	Non-amputation-free survivals% (Total n = 11)	P value
Gender	Male	40	45.5	0.8
	female	60	54.5	
Age, years		64 ± 16	73 ± 7	0.2
Ethiology	Emboli	80	54.5	0.3
	Thrombosis	20	45.5	
Rutherford grade of ischemia	2b	55.6	44.4	0.03
	3	0	100	
PAD		60.0	18.2	0.09
AF		20.0	54.5	0.2
Coronary heart disease		60	63.6	0.9
Arterial hypertension		80.0	63.6	0.5
Stroke		20.0	27.3	0.7
Hypercholisteriemia		40	45.5	0.8
CRI		40	9.1	0.1
Diabetes mellitus		20.0	45.5	0.3
Acetylsalicylic acid		0	27.3	0.2
Revascularisation	performed	100	18.2	0.002
	not performed	0	81.8	
Duration of ischemia, h		7.4 ± 3.5	22.4 ± 16.3	0.01
Duration of ischemia, h	<11 h	75	9.1	0.03
	>11 h	25	90.9	

PAD, peripheral arterial disease; *AF*, atrial fibrillation; *CRI*, chronic renal insufficiency; *h*, hour.

[a] Categorical data are presented as percentage; continuous data are presented in mean ± SD.

In accordance with the recognised optimal time for revascularisation of unilateral ALI, experimental studies using canine models demonstrated an irreversible metabolic failure of skeletal muscle with ischaemia lasting >7 h [14].

However, previously published real-world studies have reported improved amputation-free survival if the duration of unilateral ALI was up to 12 h [8, 9].

Surowiec et al. reported a higher amputation rate in a group with acute aortic thrombosis if the duration of BALI was >24 h compared to the emboli group (17.6%, 3/17 vs 6.2%, 1/16, respectively) [15].

Dossa et al. were unable to determine the critical issue of time for BALI [3]. In this study, a 6-hour threshold was used, which is similar to the experimental data and the optimal revascularisation time of unilateral ALI. This was, however, two times faster than the previously reported threshold for unilateral ALI (<12 h) [8, 9].

Crawford et al. failed to demonstrate the need for amputation based on the duration of BALI [1]. In this study, the reported time to operation was <24 h in 16 patients and >24 h in 12 patients, which is longer than that reported by Dossa et al. (time to revascularisation: 7 h, range: 3–144 h) and comparable to the current study's findings (17.7 ± 15.2 h). However, in the study by Crawford et al., patients with cancer, thrombophilia, supra- and infrarenal aortic occlusion, and visceral ischaemia were included, which may have affected the outcome.

In the current study, the mean duration of BALI (7.4 ± 3.5 h) associated with improved amputation-free survival was found to be comparable to that of unilateral ALI. However, the time frame for improving amputation-free survival following AAO was shorter (<11 h) than previously reported for unilateral ALI (<12 h) [8].

In the current study, 30-day mortality in the revascularisation group was nearly double that of the largest series ($n = 693$) evaluated by Grip and colleagues (28.6% and 15.5%, respectively) [4]. However, the study of Grip et al included a more selected patient series reported to a nationwide registry after revascularization only. Some had monolateral ischaemia and probably less severe ischaemia according to Rutherford class at clinical presentation.

The strength of the present study is the presentation of data of a more complete population of acute native aortic occlusion due to emboli or in-situ thrombosis with bilateral acute lower limb ischaemia managed by emergency transfemoral revascularization, primary major amputation or palliation. In addition, data on symptom duration of ischaemia and severity of ischaemia was accurately collected. The outcome data can be used as reference when comparing outcomes from other similar populations of acute aortic occlusion. Generalizability of the results of the present study may in fact be quite good, since it is believed that many centers around the globe uses the same approach to these patients.

The current study has limitations. The retrospective design introduced selection bias. Furthermore, a multivariate analysis of risk factors was not possible due to the small cohort size.

5. Conclusion

Larger-scale studies are required; however, a duration of BALI due to AAO of <11 h was found to be associated with improved amputation-free survival. Therefore, the routing of patients with BALI due to AAO and prehospital care protocols should be adapted to this time frame to improve outcomes.

Declarations

Author contribution statement

Denis Skrypnik: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Sultan Butaev and Artur Arakelyan: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Coral Falco, Roman Vinogradov, Alexander Baryshev and Vladimir Porhanov: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data associated with this study has been deposited at www.researchsquare.com/article/rs-669091/v1

Declaration of interest's statement

The authors declare no competing interests.

Additional information

The clinical trial described in this paper was registered at TCTR international registry under the registration number (identification no. TCTR20210609002, date of registration 09/06/2021).

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