

## Long-term Clinical Outcome and Functional Status After Arterial Reconstruction in Upper Extremity Injury

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### WHAT THIS PAPER ADDS

Long-term functional outcome using the Disabilities of Arm, Shoulder, and Hand (DASH) score after repair of arterial lesions in upper extremity injury is presented. The 30 item DASH questionnaire conceptualizes the upper extremity as a single functional unit, and refers to the patient's everyday activities. High DASH scores indicate high grades of disability of the affected limb. For the first time, significant functional long term deficits, assessed by DASH scores, are shown in two groups of patients (those with associated neurological injuries, and those with initial limb ischemia without neurological concomitants) after repair of upper limb arterial lesions.

**Objective/Background:** To analyse long term outcome, including functional status and prognostic factors, in patients who have undergone arterial repair of civilian upper limb injury. Retrospective data analysis of prospectively collected data was performed.

**Methods:** This was a retrospective data analysis of prospectively collected data. Records of all patients who had undergone repair of traumatic arterial lesions in the upper limb between 1989 and 2010 were reviewed, and clinical follow up was performed. End points were: long term patency, measured by color Doppler ultrasound; vascular re-intervention; limb salvage rate; and long term functional status using the Disabilities of Arm, Shoulder, and Hand (DASH) questionnaire. The DASH questionnaire is an instrument used to identify a patient's disabilities, in which everyday activities are assessed by 30 questions. The DASH answers are summarized and, using a conversion formula, lead to a score between 0 (full recovery) and 100 (severe disability). The DASH questionnaire was sent to all German-speaking individuals for data supplementation after completion of a clinical follow up study.

**Results:** A total of 117 arterial repairs were performed in 108 patients (87 men, median age 35.7 years). Blunt trauma was the predominant cause of injury ( $n = 96$ ; 82%). Accompanying nerve lesions ( $n = 39$ ; 36%) and/or orthopedic injuries ( $n = 65$ ; 60%) were present in 84 patients (78%). After a median follow up time of 5.3 years (range 0.5–19.7 years), 65 patients (60%) were re-investigated: long-term patency was 97%. The DASH questionnaire was answered by 57 patients (53%). Functional impairment was frequently seen, and determined by neurological injury (including neurological lesions, median DASH score was 40.3 [range 3.5–69.8] vs. 0.8 [range 0–5.8] without;  $p < .001$ ) and ischemia at time of injury (median DASH score with ischemia 4.2 [range 0–16.9] vs. 0.0 [0–1.7] without;  $p < .04$ ).

**Conclusion:** Favorable long term patency rates after arterial repair in upper extremity injuries can be achieved. Long term functional impairment is a significant problem and determined by associated neurological injury, as well as ischemia at time of injury.

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### INTRODUCTION

There is a lack of data in the current literature on long-term functional outcome after repair of traumatic arterial lesions in the upper extremity. To the authors' knowledge, only six series with a follow up >6 months have been published.<sup>1–6</sup>

In summary, these studies have shown that the mechanism of injury is essential: penetrating trauma is usually characterized by limited damage within a limited area and few accompanying lesions; blunt trauma is more frequently associated with neurological and orthopedic injuries and is therefore demonstrated to lead to a significantly higher rate of disability.<sup>1–5,7–14</sup>

The present study is a retrospective outcome analysis aimed at evaluation of functional results using the Disabilities of Arm, Shoulder, and Hand (DASH) score in a

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consecutive series of patients who had undergone arterial repair in upper extremity injuries treated at the Medical University of Innsbruck, Innsbruck, Austria, a level I trauma center. Clinical data of the subgroup of patients with blunt trauma have been reported previously.<sup>15</sup>

## MATERIALS AND METHODS

All patients who had undergone repair of arterial injuries as a result of upper limb trauma from 1989 to 2010 at the Medical University of Innsbruck, Innsbruck, Austria, a level I trauma center, were invited for clinical follow up studies, which included physical examination, bilateral segmental blood pressure evaluation and calculation of arterial pressure indices, and duplex ultrasound. In addition, to measure self reported functional disability, all individuals were asked to complete the DASH questionnaire.<sup>16–19</sup> It took some time to receive completed questionnaires from a sufficient number of patients, which delayed the evaluation. The DASH questionnaire was sent to all participants in 2010. Therefore, there was no predefined time interval between injury and answering the questionnaire. The 30 item DASH questionnaire conceptualizes the upper extremity as a single functional unit, and refers to a patient's everyday activities. The questionnaire has been extensively validated and frequently used to assess wrist and hand function in patients with different diseases and injuries.<sup>16–24</sup> The DASH answers are summarized and, using a conversion formula, give a score between 0 (full recovery) and 100 (severe disability). The validated German version of the DASH questionnaire was sent to living, German-speaking individuals ( $n = 85$ ) and was answered by 57 patients (67%).<sup>18</sup>

Data collection included demographic parameters, mechanism of injury, location and type of arterial lesion, presence of ischemia defined by signs and symptoms that are characterized by the six "ps" (pulselessness, pallor, pain, poikilothermia, paresthesia, and paralysis), severity of hand ischemia classified according to Rutherford in categories I–III,<sup>25</sup> presence of concomitant injuries (vein, nerve, bone and/or joint), and details of arterial reconstruction. For outcome analysis, long-term patency of arterial repair, vascular re-intervention, limb salvage rate, and functional impairment, as detected by DASH scores, were calculated. Statistical analysis was performed using descriptive statistics, and median and quartiles of DASH scores were calculated. Subgroup analysis and comparison of DASH scores was performed using the Mann–Whitney  $U$  test, which was considered significant at  $p < .05$ .

Study design was constructed according to the guidelines of the institutional review board.

## RESULTS

A total of 108 consecutive patients (87 men, median age 35.7 years [range 2.5–87.6]) underwent reconstruction of 117 injured arteries of the upper extremity. The majority of lesions ( $n = 96$ ; 82%) were caused by a blunt injuries, 10 by penetrating trauma, and 11 were iatrogenic. Clinical data in the cohort with blunt injuries have been published

previously.<sup>15</sup> The left extremity was involved in 64 lesions, the right extremity in 53. Arteries injured included the subclavian ( $n = 24$ ; 20.5%), axillary ( $n = 22$ ; 18.8%), brachial ( $n = 53$ ; 45.3%), radial ( $n = 13$ ; 11.1%), and ulnar ( $n = 5$ ; 4.3%). Forty-three patients (40%) presented with limb ischemia. Accompanying nerve injuries ( $n = 39$ ; 36%) and/or orthopedic injuries ( $n = 65$ ; 60%) were present in 84 patients (78%). Nerve trauma included 21 patients with brachial plexus injuries, and 18 patients with isolated or combined injuries to the median ( $n = 13$ ), ulnar ( $n = 8$ ), radial ( $n = 8$ ), musculocutaneous ( $n = 4$ ), axillary ( $n = 1$ ), and/or suprascapular ( $n = 1$ ) nerve. Orthopedic lesions included 53 fractures and 21 luxations. A total of 14 patients (13%) had severe concomitant injuries to the head or neck ( $n = 9$ ), chest ( $n = 5$ ), abdomen ( $n = 3$ ) and/or vertebral column ( $n = 2$ ).

Within 30 days post-surgery, five patients (with five arterial repairs) died and two patients (with three arterial reconstructions) were amputated (major amputation) at the upper arm level because of severe, life threatening wound infection. At the time of discharge from the hospital, 108 of 109 arterial repairs were patent (secondary patency rate 99%). Patency was measured by color Doppler ultrasound.

Long-term clinical follow up data were available for 65 patients (60%) after a median follow up period of 5.3 years (range 0.5–19.7 years). During this time, 12 patients had died, although none as a consequence of previous upper limb injury. No patient underwent secondary amputation. Amputation was discussed if there were severe functional deficits, but all patients preferred to preserve the limb. None of the patients required vascular re-operation or re-intervention; however, two individuals were detected with occluded arterial repairs and another two patients had a high grade stenosis at the repaired arterial segment during follow up. All patients were asymptomatic and therefore treated conservatively. Long term patency was 97%. DASH scores showed wide inter-individual variations. Subgroup analysis measured higher scores in patients with associated neurological injuries (median + quartiles) (with neurological lesion, the DASH score was 40.3 [range 3.5–69.8] vs. 0.8 [range 0.0–5.8] without neurological lesion;  $p < .001$ ). Among patients with neurological lesions, those with concomitant plexus lesions did not perform worse on the DASH questionnaire than patients with other peripheral nerve injuries. As a consequence of frequently associated neurological lesions, patients with injuries to the subclavian and axillary arteries had higher disability (subclavian and axillary artery [proximal] DASH score 37.2 [range 0–69.6]) than patients with brachial or forearm arterial injuries (brachial artery and forearm artery [distal] DASH score 1.7 [0–6.7];  $p = .017$ ). In addition, patients presenting with ischemia at time of injury without neurological injuries had higher disability scores (ischemia DASH score 4.2 [range 0–16.9] vs. 0 [range 0–1.7]) than those with no ischemia ( $p = .04$ ). Comparison of DASH scores in patients with blunt ( $n = 53$ ) versus penetrating ( $n = 4$ ) trauma was hampered by the small number of patients with penetrating injuries, which did not allow statistical analysis. On the one hand,

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