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Which Concomitant Arterial Injury in the Forearm Tends to Mess Up the Hand More

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ABSTRACT

Introduction: This study focuses on the differences of concomitant single forearm arterial (radial & ulnar) injuries. The ulnar artery has been being consented to be the dominant one of the hand for a long time despite more recent and controversial studies clinical observations might be supporting it.

Material and Method: We assessed 108 consecutive, minimum 1-year followed-up, concomitant single artery lacerated forearm injuries operated in our clinic retrospectively, and 38 cases attended. After attendees filled subjective questionnaires, we evaluated their hand circulation, hand sensation, handgrip, pinch-grip, and thermo-distribution.

Results: Most common injury type was glass cut (62%), followed by power saw injury (26%). Cases associated with the ulnar artery lacerations were referred to the hospital with significantly (p<0,05) more severe injuries, which appeared to be significantly (p<0,001) associated with the ulnar nerve lesion that appeared to be the most significant (p<0,05) parameter affecting clinical outcomes. Moreover, patency rates for artery repairs were 71% (27/38) similar to the literature and surprisingly, smoking didn't affect arterial patency among our patients (n=22, 57,8% smoker).

Conclusion: The ulnar artery is at greater risk due to the most common injury mechanism, and the ulnar nerve associates nearly each ulnar artery laceration and eventuates in certain disability levels. Hence why we are encouraged to consider the medial side of the forearm as strategically valuable and the ulnar artery as the major troublemaker in forearm injuries functionality wise.

Key Words: Radial, Ulnar artery, Ulnar nerve, Forearm injury, Glass punch, Hand functionality

INTRODUCTION AND BACKGROUND

Forearm arteries have been a dispute over years and still, there is not a strong consensus on whether radial or ulnar artery is dominant regarding the hand perfusion or at least which one is of an anatomically critical area. Our opinion was that hand perfusion was singular and all the anatomical structures were at the same significance level, yet the medial side of the forearm should be considered more vulnerable, and the ulnar artery should attain more critical care when injured. This was the baseline of our study.[1,2]

We coped with serious cooperation issues throughout the study due to the nature of trauma with thickly involved glass punchers and the attendance was similar to the literature.[1]

Nearly half (45,4%) of all upper extremity injuries happen indoors[2]. Penetrating traumas are responsible for 80% of all upper extremity injuries, and upper extremity vascular traumas are for 50% of all peripheral vascular injuries.[3] Postoperative arterial patency rates are reported as diverse as 50-77%.[4] Glass-punchers are usually young adults with 28,5 mean age with their dominant hands affected [5, 6] whereas power-tool users frequently injure their non-dominant hands due to the most common usage style.[7] A study on teenagers and young adults has shown that 86% of all disability-causing injuries are related to the hand and upper extremity, also hand injury is the top reason accounting for work-related disabilities.[8] Trybus et al.[9] reported that 26,6% of all cases consumed alcohol before the hand injury, 89,3% of them were young adults and 74,3% manual workers, 65,9% of injuries happened at home, mostly by glass and healthcare expenses of these patients altered twice that of non-alcohol related injuries. Another study reports that with a 48% majority among all power-tool related injuries, upper extremity

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dominates the list of injured organs including craniofacial and torso, males lead 95% of this population and it takes them at least 3 months to recover.[10]

Despite the anatomical prominence of any given structure in the forearm regarding the hand, in some cases, a well-perfused hand becomes an excuse for ignoring a single arterial rupture which we think should not even be considered ligating if mangled extremity is not present.

MATERIAL AND METHODS

The study was approved by the local ethical committee under case no: 18-12.1T/35. The study is retrospective. The main objective was to assess the clinical outcomes of forearm injuries with a neurovascular component and assign the prominence of one major artery in hand perfusion.

Initially, 3908 individual case files with upper extremity trauma operated in our clinic, between September 2014 – March 2018 were revealed. Any single forearm artery laceration of any age and sex was included. Regarding homogeneity, patients with severe injuries requiring emergent revascularization such as total or subtotal amputation, with irregular or incomplete outpatient clinic visits, severely senile, immobilized, debilitated, also hardly cooperating pediatric ages under ten years old and any concomitant hand injuries were excluded. Eventually, 108 cases were registered and 38 people attended the further examination.

According to dossier research, all the cases were operated under a 4.3x magnifying loupe. Microsurgical procedures were done with non-absorbable 8/0 and 9/0 polypropylene sutures. All the cases were treated at least 5 days with the same regimen:

1. Full immobilization
2. Pentoxifylline added Dextran 40 solution infused throughout 72 hours
3. HMWH daily
4. Salicylate daily

Arterial patency was assessed via 8.0 MHz probe Mobile Doppler Ultrasonography (MDU) [11-13]. Meanwhile, minimal reverberations in perfusion were monitored via a portable pulse oximeter put on the third finger pulp. [14,15]

Each MDU examination was recorded and rendered via audio-analyzer (Figure 1).[16] Non-directional MDU audios were designated as triphasic, biphasic and monophasic/non-patent.

Concomitant nerve damage was assessed via Semmes-Weinstein[17,18,19] monofilaments and Weber's[20] two-point discrimination and tactile gnosis. Posttraumatic cold-related (cold intolerance) symptoms[21] were also evaluated. Palmar grip and key-pinch forces were assessed. FLIR ONE® was used to establish warm-cool divergence values. Images were generated at standard 30cm apart with 0-30° angle, then analyzed via FLIR Tools App. and processed through ANOVA to distinguish temperature variance between healthy and pathologic specimens.

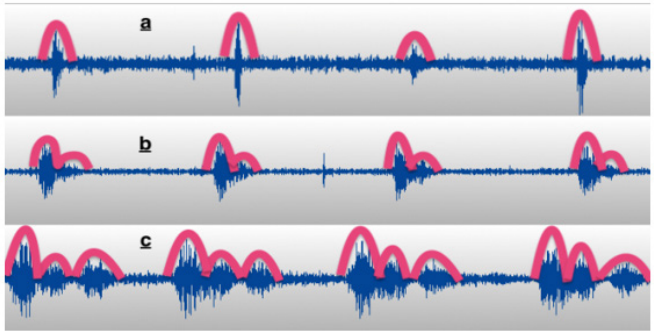

Figure 1: Non-directional manual doppler ultrasound audio files. a-monophasic, b-biphasic, c-triphasic.

A well-known scoring system MHISS (Managed Hand Injury Severity Score)[1] designed especially for forearm lacerations was used to assess the severity of the injury. Also, a well-known patient-reported outcome QDASH (Quick – Disabilities of Arm, Shoulder, and Hand) [22] scoring for clinical assessment was used.

STATISTICAL ANALYSIS

SPSS 25 was used for statistical analysis (CI=95%,p<,05). Comprehensively, Kolmogorov-Smirnoff, Shapiro-Wilk, Levene, Mann-Whitney U, Pearson Qi square, Student's t, Goodman Kruskal Tau, Lambda, Kruskal Wallis, ANOVA and ROC tests were used.

RESULTS

Study population (n=38) distributed between 10-82 with 34,5 median age. 26 (68.4%) right and 12 (31.6%) left side injuries, also, 26 dominant side injuries and 12 non-dominant side injuries were registered. Overall, 95% of the whole population was right dominant by nature.

12 (31,6%) radial arteries and 26 (68,4%) ulnar arteries were registered.

Either median or ulnar nerve accompanied 76,3% of all cases and 13,1% of cases involved both. The ulnar nerve demonstrated significant concomitance (p<,001) with the ulnar artery due to the anatomical course.

MHIS scores distributed into the radial and the ulnar artery groups, where the ulnar artery group significantly (p<,05) altered, meaning the ulnar artery accompanied to more severe traumas, which by all means explains the strategic importance

of the medial side of the forearm and the ulnar artery neighbourhood. Glass-punchers exhibited significantly higher (p<,05) arterial patency, possibly because of the minimal structural damage to the artery, likewise significantly better (p<,05) outcomes. According to age groups, radial artery demonstrated a significant concordance (p<,05) along with the senior ages, which hereby may explain the better outcomes of young glass killers.

The radial artery group showed significantly better (p<,05) results than the ulnar artery group in terms of key-pinch force due to the high concordance of the ulnar artery and the ulnar nerve. Moreover, nearly a quarter (23,6%) portion of QDASH variations could be explained by given forces, furthermore, a 1 kg increase in key-pinch, resulted in a 3,09 unit decrease in QDASH score. Key-pinch also resembled to have a significantly more prominent (p<,001) impact on QDASH variations.

Active smokers (57,8%) during and after the injury were identified as smokers. As expected, smoking significantly (p<,05) deteriorated QDASH clinical outcomes, in contrast, arterial patency didn't correlate with smoking.

Finally, ANOVA applied to assess the correlation of cold intolerance with the coolest and the warmest spots evaluated via thermal distribution. The coolest temperature had a significant correlation (p<,001) with the cold intolerance, hypothetically ensuing the feeling of cold as not only a paresthetic sensation the hand could be unnaturally cold.

Triphasic ultrasound patterns exhibited a 71% (27/38) artery patency rate. Nevertheless, artery patency didn't significantly correlate with outcomes.

DISCUSSION

QDASH score represents one of the most reliable patients reported outcomes in literature [23-26] hence, we believe our research brought out confident evidence.

Standard Occupational Classification 2000 (SOC-2000) [27] is widely used among occupational injury researchers, whereas our research wasn't compatible because of the insufficient members falling into each group. We roughly determined 'heavy worker' and 'not heavy worker' groups, yet no significant difference concerning injury severity, clinical outcome, etc. achieved even in this custom.

Clinical example case no: 9 (Figure 2). This case was a glass-puncher with the ulnar artery laceration, monophasic non-patent doppler pattern, and symptomatic claudication. The little finger seemed dimmer than others, most probably because of the hypoperfusion in this particular finger which sits closer to the congested ulnar artery. Recall that, patients had no associated hand injuries whatsoever. Standalone this case supports our anti-ligation policy.

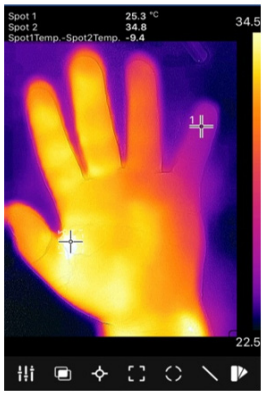

Figure 2: Congested ulnar artery and hypoperfused little finger.

The real-time surface thermal analysis opens an opportunity for a comprehensive approach to posttraumatic cold-related symptoms. Our study population involved only patients which attained a challenge establishing normative values. Thermal imaging advocates prospective value for early and late hand perfusion periods but needs more quantitative studies to establish a proper normative pitch for desired natural perfusion of the hand.

Single major nerve injury accompanies 58% of the forearm arterial lacerations according to Ballard et al.[28] and 86% in Keleş et al.[29]. We noted 76,3% single and 13,1% dual major nerve injuries similarly in our study.

According to Bacakoglu et al.[4] Doppler US exhibited 93,7% arterial patency whereas the angiography (gold standard) did 69. 2%, thus 14.6% α error assigned to Doppler US in forearm arterial lacerations. The sound wave pattern in non-directional MDU was described a couple of years later,[30] so there's a possibility that radiologists misinterpreted all mono and biphasic patterns as a patent. Nevertheless, 71% (27/38) arterial patency is a similar result with the literature.[28,31].

During the strike, glass is shattered, yet we think not the punch itself causes the laceration, pulling it out does. More forceful the fist dives into pieces, the more deeply they cut the forearm. This behaviour is called impulsiveness in psychiatry,[29-32] so it mentions the fail to struggle with stress factors, thus being compelled into self-destructive action. The aetiology is described as sparking with an impulsive energy blast, which therefore causes an urge for self-destruction by striking somewhere, usually the glass which vaguely reflects the image of one's self.

CONCLUSION

The majority of the population were impulsive glass-puncher young males with the right dominant side and the injured ulnar artery. Ulnar artery lacerations demonstrated more severe injuries than the radial artery according to MHISS. Nearly every ulnar artery associated with the ulnar nerve.

Furthermore, both motor and sensory functions of the ulnar nerve had a significantly higher impact on clinical outcomes. We still believe ruddy hand perfusion develops due to the hefty usage of the hand, and each artery course improves by the nature of the labour if not the profession which is another subject for a novel study. It is clinically explicit that hand perfusion is singular and every disrupted anatomical structure needs the same medical care, and despite the radial artery being the major labourer for the hand, we are encouraged to establish the ulnar artery as the weightier concomitant trouble maker in forearm injuries functionality wise.

EThical CommIttee Approval

The study protocol received institutional review board approval under Case No: 18-12.1T/35 on 26.12.2018 and all participants provided informed consent in the required format.

COnflict of Interest

Research contributors declare there has been no conflict of interest whatsoever.

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Author's Contribution

Mirzazada Javad and Kucuk Levent conceived of the presented idea. Mirzazada J. developed the theory and performed the computations, verified the analytical methods. Kucuk L. encouraged Mirzazada J. to investigate hand perfusion after forearm trauma and supervised the findings of this work. Both authors discussed the results and contributed to the final manuscript.

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