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Soft Tissue Reconstruction of the Upper Limb Following Blast Injuries: A Seven-Year Institutional Experience with Local Flaps at Ghazi Al-Hariri Hospital for Surgical Specialties, Baghdad Medical City, Iraq

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Abstract

Background: The long history of war in Iraq has created a high level of high-blast upper limb trauma that necessitates a complicated reconstruction process. The tissue defects resulting with improvised explosive devices and other munitions require solid wound coverage to maintain limb viability and functionality. Free tissue transfer is not always possible in resource-limited health care settings like Baghdad Medical City, thus pedicled local flaps is the main mode of reconstruction in healthcare.

Objectives: To compare the clinical outcomes, functional recovery, and resource efficiency of local flaps reconstruction of upper limb soft tissue defects caused by blast injuries, and treated over seven years at a national tertiary referral centre in Iraq.

Methods: A retrospective cohort study was carried out in Ghazi Al-Hariri Hospital of Surgical Specialties (GAHHSS), Baghdad Medical City in January 2017 to December 2023. One hundred and twenty-two (112) patients who met pre-specified criteria of inclusion were enrolled. Standardised data extraction involved demographics, injury severity (Gustilo-Anderson classification), flap, and postoperative outcomes. At three and six months, functional recovery was measured by means of the Arabic version of Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. The flap choice was controlled by the a priori institutional algorithm, based on the anatomical zone and the size of defects. IBM SPSS v28.0 was used to conduct the statistical analysis; Chi-square and Fisher exact tests were used to compare categorical variables, and multivariate logistic regression was used to determine independent predictors of flap failure (significance level $p < 0.05$).

Results: In 112 patients (mean age 27.6 9.3, 92.0% males), improvised explosive devices were the cause of 69.6 percent of injuries. The commonly injured area was the dorsum of the hand (33.0%), then forearm

(28.0%), and wrist (24.1). Eight different local flap methods were used; the most commonly used ones were the dorsal metacarpal artery flap (25.9%), and the radial forearm adipofascial flap (19.6%). The total survival rate of people at the flaps was 91.1%. Infected wound cases were 8.0 per cent and re-operation 9.8. The average DASH score increased significantly between three months and six months (28.4: 11.2 and 19.1: 9.8) (p = 0.001). Two out of three patients (67.9) went back to pre-injury activities in six months. Local flaps took significantly less operative time (102 vs. 385 minutes), shorter intensive care unit (0.4 vs. 3.2 days) and cost per case (420 vs. 2850) than free tissue transfer.

Conclusions: Local pedicled flaps, when chosen and utilized in a guided anatomical procedure, result in the same results that are presented in high-income systems and give incontrovertible logistical and economic benefits in resource-constrained systems. The wider implementation of this algorithm in local trauma departments and the inclusion of this algorithm into the national surgery education programs are highly advised.

Keywords: Local flaps; blast injuries; upper limb reconstruction; soft tissue coverage; war trauma; DASH score; Iraq; reconstructive surgery; resource-limited settings

Introduction

The decades of continuous armed conflict in Iraq during the wars with Iran (19801988), subsequent Gulf Wars, and even decades of counter-insurgency campaigns continue till 2017 has caused an epidemic of traumatic injuries related to blasts (Al-Obaidi et al., 2021). Improvved explosive devices (IED), mortar shells, artillery fragments, and unexploded ordnance are all classified as munitions which cause characteristic high-energy wounds, a combination of overpressure, fragmentation, thermal injury, and ground impact. The tissue defects pathogenic are in most cases composite and interrupt all the integument, subcutaneous fat, musculotendinous units, peripheral nerves, vascular conduits and skeletal structures (Hettiaratchy et al., 2010).

The burden of this injury falls disproportionately on the upper extremity, as it is exposed to this injury both in the course of the occupation and in combat confrontations. Iraqi trauma registry data show that 38-45% of presentations of blast-casualty involve the upper limbs (Al-Dabbagh and Al-Hadithy, 2019). Inability to attain durable, well-vascularised soft tissue coverage at a timely time has dire consequences, such as osteomyelitis, tendon necrosis, progressive joint contracture, neuropathic pain, and eventual limb loss, which added to the already significant socioeconomic sequelae witnessed by the people and society in the post-conflict Iraq (Clasper et al., 2019).

Even though free tissue transfer is generally accepted as the gold standard of complex composite defects above 20 cm 2 in high-income surgical practice, its standard practice use in the Iraqi tertiary hospital context is limited by several systemic factors. They include the lack of consistent access to specialized microsurgical operating rooms with suitable equipment, shortage of trained microsurgical units, unreliable postoperative surveillance facilities, long operation times that use limited theatre time, and prohibitive per-case prices in a state-funded health care system that accommodates millions of patients (Al-Dabbagh, 2019; Ministry of Health, 2022).

An alternative of strategic interest here is the use of pedicled local flaps - tissue units removed and reinserted into a neighbouring recipient bed whilst preserving their indigenous axial or perforator-based blood supply. These procedures are possible as one operative procedure with little specialised equipment,

retention of donor-site regional anatomy and can be technically reproducible by trained reconstructive surgeons without microsurgical skills. Importantly, they are in line with the set principles of the proper surgical technology promoted by the Lancet Commission on Global Surgery: efficient, affordable, educable, and attainable within the current health system capability (Meara et al., 2015).

Ghazi Al-Hariri Hospital of Surgical Specialties (GAHHSS) is a non-profit surgical specialty and special referral hospital founded in 2010 as a subsidiary of Baghdad Medical City. The Department of Plastic and Reconstructive Surgery attends to over 1,200 major cases of reconstruction each year, the most common being the cases of the blast related defects of the upper limbs. Since 2017 a standardised anatomy-inspired local flap algorithm that prefers axial-pattern flaps to random-pattern designs has been operational using multidisciplinary consensus.

The current research provides the largest and methodologically most sound single centred series of local flap reconstruction of upper limbs that were affected by blasts that have taken place in an Iraqi surgical centre. In addition to validating the flap-specific data on survival, the study offers a granular functional recovery measure, multivariate predictors of adverse outcomes, and comparative resource utilisation standards information, which can all be used to support clinical practice and health policy in conflict-affected low- and middle-income countries.

Materials and methods

2.1 Study Design and Ethical Approval

This retrospective cohort study compared adult and adolescent patients with local flap reconstruction of upper limb soft tissue defects caused by blast at GAHHSS in the period 1 January 2017 to 31 December 2023. It was approved by the Research Ethics Committee of Baghdad Medical City (Reference: BMCREC-2024-017) and all the procedures were performed in compliance with the ethical principles, which were codified in the Declaration of Helsinki (Baghdad Medical City Research Ethics Committee, 2024). Retrospective quality of data in anonymised clinical record, and the lack of identifying patient details, along with the absence of identifiable information in the records, mandated no special incorporation of informed consent, formally forfeited by the approving committee.

2.2 Study Setting

GAHHSS is a 200 bed specialist surgical hospital in the city of Baghdad Medical City the largest medical complex in Iraq. The center has three specialty plastic and reconstructive surgery theatres, is the national referral centre of limb salvage and post-conflict reconstruction, and accepts transfer of field hospital patients, provincial trauma centres, and civilian emergency department patients in twelve governorates. The reconstruction surgery team includes five senior consultant plastic surgeons with a minimum ten years experience in handling of blast-related trauma.

2.3 Eligibility Criteria

To satisfy inclusion criteria, participants had to meet the following criteria: (i) age 14 years or older; (ii) upper limb soft tissue defect due to a proven blast mechanism (IED, mortar, grenade or unexploded ordnance reported in operative record); (iii) definitive wound coverage with pedicled local flap (i.e. tissue transposed, rotated or advanced without microvascular anastomosis); and (iv) a minimum of six months post-reconstruction follow up.

Exclusion criteria included the presentation of patients with superficial abrasions or minor lacerations, and or healing did not necessitate a flap repair; the healing was only done through split-thickness skin

grafts or free flaps; poor documentation of medical history, and or lack of follow-up over a six-month period; ipsilateral or contralateral amputation, and or amputation that precluded meaningful functional evaluation.

2.4 Data Collection and Variables.

The data were retrieved in electronic surgical logs, paper-based inpatient records, outpatient clinic files, and photographic archive, by two independent reviewers. The discrepancies were decided by mutual agreement with a third senior reviewer. The demographic variables were age, sex, occupation, civilian or military status and comorbid conditions. Variables related to injury included the blast mechanism, the location of the defect (out of five zones: fingertips, hand, wrist, forearm, elbow/upper arm) and surface area of the defect (length x width in cm 2, measured intraoperative), and tissue loss depth, related skeletal injury, and neurovascular injury, as well as wound severity on the modified GustiloAnderson classification applied to blast wounds (Pollak et al., 2006). The surgical criteria were flap design, foundation, size, origin, duration of operation, and adjunctive procedures. Outcome variables included flap viability 30 days (full survival, partial necrosis over 30% of surface area, total necrosis), wound complications (infection based on CDC criteria, dehiscence, haematoma, seroma), reoperation, functional recovery using Arabic DASH questionnaire at three and six months, six-month return to pre-injury activity, and patient-reported satisfaction on a five-point Likert scale (Al-Hadithy et al., 2018).

2.5 Surgical protocol and the algorithm of Flap selection.

The emergency wound debridement was performed within 24 hours of admission on all patients under the guidelines of damage-control surgery, including the removal of non-viable tissue and foreign material and irrigation and the application of saline-impregnated dressings or negative-pressure wound treatment (where available). Perioperative antibiotic prophylaxis included cefazolin and metronidazole which was continued five to seven days after reconstruction.

Absolute flap coverage was not applied until a clean well-granulating wound bed was achieved - usually between days three and seven following injury. Choice of flap was based on the validated GAHHSS institutional algorithm (Figure 5) that uses anatomical-zone-specific reconstructive choices with a premeditated bias toward axial-pattern design at the expense of random-pattern design. Some of the key decision pathways are: V-Y advancement or thenar flap in the case of defects in the fingertips; dorsal metacarpal artery flap in the case of defects in the dorsal hand; anterior interosseous artery (PIA) propeller flap or radial artery perforator flap in the case of wrist coverage; radial or ulnar artery-based adipofascial rotation flap in the case of forearm defects; and brachioradialis advancement or modified deltopectoral flap All flaps were subjected to the mapping procedure of perforator using handheld 8 MHz Doppler ultrasonography before the operation.

2.6 Postoperative Management

The burn unit surgical ward was assessed clinically on hourly basis on the first 24 hours and four-hourly basis on the first 72 hours of the surgical floor with regard to flap perfusion. It was not necessary to have routine admission to intensive care unit unless the admission was determined by concurrent medical conditions. Standardisation was done on limbs elevation, analgesic optimisation, and antibiotic continuance. Postoperative days 10-14 Sutures were taken out. Formal hand therapy, guided by licensed occupational therapists, started on the fifth day after surgery and included eccentric passive and active range-of-motion exercises.

2.7 Statistical Analysis

Data collected was put into a password protected REDCap database and analysed with the help of IBM SPSS statistics version 28.0. Shapiro-Wilk test was used to test the distributional normality of the continuous variables which were then reported as a mean with standard deviation or median with the interquartile as the case may be. Absolute frequencies and percentages were used in expressing categorical variables. The 95% confidence intervals were given on flap survival rates and complication rates. Chi-square, Fisher exact, independent-samples t or Mann-Whitney U tests were used as univariate tests of association between predictor variables (defect size, Gustilo grade, flap type) and dichotomous outcomes (flap failure, infection). To estimate independent predictors of flap necrosis, multivariate binary logistic regression, which controls the identified confounding factors, was used. Repeated-measures ANOVA was employed to assess the temporal variations in the scores of DASH. Time to complication and reoperation was illustrated in Kaplan-Meier survival analysis. All tests were two-tailed; the p-value below 0.05 was considered to be statistically significant.

Results

3.1 Patient Demographics and Injury Profile

A total of 112 patients satisfying all inclusion criteria were enrolled. The cohort was predominantly composed of young adult males — mean age 27.6 ± 9.3 years (range 14–58), 103 males (92.0%) and 9 females (8.0%) — consistent with the demographic profile of individuals most exposed to blast-related hazards in conflict environments. Civilian status was documented in 79.5% of patients, with the remaining 20.5% comprising military or law enforcement personnel. The prevalence of relevant comorbidities was low: diabetes mellitus in 3.6%, hypertension in 2.7%, and active tobacco use in 27.7%. Demographic and injury characteristics are summarised in Table 1.

Table 1. Demographic and Injury Characteristics of the Study Cohort (n = 112)

Variable	Value
Age (years), mean ± SD	27.6 ± 9.3
Age range (years)	14–58
Sex — Male, n (%)	103 (92.0%)
Sex — Female, n (%)	9 (8.0%)
Civilian status, n (%)	89 (79.5%)
Military/Police, n (%)	23 (20.5%)
IED blast mechanism, n (%)	78 (69.6%)
Mortar shell, n (%)	21 (18.8%)
Grenade, n (%)	9 (8.0%)
UXO, n (%)	4 (3.6%)
Gustilo IIIA, n (%)	44 (39.3%)

Gustilo IIIB, n (%)	56 (50.0%)
Gustilo IIIC, n (%)	12 (10.7%)
Tendon exposure, n (%)	94 (83.9%)
Bone exposure, n (%)	47 (42.0%)
Associated fractures, n (%)	68 (60.7%)
Nerve injury, n (%)	31 (27.7%)
Time to presentation, median (IQR)	3 days (1–7)
Time to definitive flap coverage, median (IQR)	5 days (3–7)

IED = improvised explosive device; UXO = unexploded ordnance; IQR = interquartile range.

3.2 Flap Distribution and Utilisation

Eight distinct local flap procedures were deployed in accordance with the anatomical zone algorithm. The dorsal metacarpal artery flap (DMA) was the most frequently employed technique (n = 29, 25.9%), followed by the radial forearm adipofascial flap (n = 22, 19.6%) and the posterior interosseous artery propeller flap (n = 18, 16.1%). The median interval from injury to definitive flap coverage was five days (IQR: 3–7). The overall mean defect surface area was 28.7 ± 14.3 cm², ranging from 2.1 cm² (fingertip) to 72.0 cm² (proximal forearm). Flap distribution by anatomical region is detailed in Table 2.

Table 2. Distribution of Local Flap Types by Anatomic Region (n = 112)

Anatomic Region	Flap Type	n (%)	Flap Size cm² (mean±SD)	Survival n (%)
Fingertips	V-Y Advancement	8 (7.1%)	2.8 ± 1.1	8 (100%)
Hand (dorsum)	Dorsal Metacarpal Artery Flap	29 (25.9%)	17.4 ± 5.2	28 (96.6%)
Hand (palm)	Thenar Flap	6 (5.4%)	8.3 ± 2.4	6 (100%)
Wrist	PIA Propeller Flap	18 (16.1%)	24.7 ± 6.8	16 (88.9%)
Wrist	Radial Artery Perforator Flap	7 (6.3%)	22.1 ± 5.9	7 (100%)
Forearm	Radial Forearm Adipofascial Flap	22 (19.6%)	35.2 ± 9.1	20 (90.9%)
Forearm	Ulnar Artery Rotation Flap	9 (8.0%)	38.5 ± 10.2	8 (88.9%)

Elbow	Brachioradialis Advancement Flap	8 (7.1%)	42.0 ± 7.5	7 (87.5%)
Upper Arm	Modified Deltopectoral Flap	5 (4.5%)	48.6 ± 11.3	4 (80.0%)
Total	—	**112 (100%)**	**28.7 ± 14.3**	**102 (91.1%)**

PIA = posterior interosseous artery; SD = standard deviation.

3.3 Flap Survival and Complications

Full recovery of flaps was done in 102 out of 112 patients resulting in a combined survival rate of 91.1. Three patients were lost to total flap loss (2.7 percent), and all of them had Gustilo type IIIC injuries with the presence of interruption of regional vascular inflow. Seven cases reported partial necrosis with over 30 percent of the flap surface (6.3 percent), with PIA propeller and radial forearm adipofascia groups being disproportionately involved - probably because of venous congestion in dirty wound areas. It was established that nine patients had surgical site infection (8.0%), microbiological culture was made in six patients with Staphylococcus aureus and Pseudomonas aeruginosa being the most common organisms. There were six cases of wound dehiscence (5.4%), mostly at tension-bearing inset margins. Eleven patients (9.8%) had to be reoperated, including seven debridement and resuturing operations and four second applications of skin grafts to residual flaps. The V-Y progression and thenar flaps featured zero complication (100% survival), whereas the modified deltopectoral flap a random pattern flap only applied in the most proximate defects featured the worst complication profile (40% combined, with 20% total loss rate). Table 3 gives the data on complications by the type of flaps.

Table 3. Postoperative Complications by Flap Type (n = 112)

Flap Type	n	Partial Necrosis n (%)	Infection n (%)	Complete Loss n (%)	Total Complications n (%)
Dorsal Metacarpal Artery	29	1 (3.4%)	1 (3.4%)	0 (0.0%)	1 (3.4%)
V-Y Advancement	8	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Thenar Flap	6	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
PIA Propeller	18	2 (11.1%)	2 (11.1%)	0 (0.0%)	3 (16.7%)
Radial Artery Perforator	7	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Radial Forearm Adipofascial	22	2 (9.1%)	2 (9.1%)	1 (4.5%)	3 (13.6%)

Ulnar Rotation Flap	9	1 (11.1%)	1 (11.1%)	0 (0.0%)	1 (11.1%)
Brachioradialis Advancement	8	1 (12.5%)	1 (12.5%)	0 (0.0%)	1 (12.5%)
Modified Deltopectoral	5	1 (20.0%)	1 (20.0%)	1 (20.0%)	2 (40.0%)
Total	**112**	**9 (8.0%)**	**7 (6.3%)**	**3 (2.7%)**	**11 (9.8%)**

PIA = posterior interosseous artery.

3.4 Functional and Socioeconomic Outcomes

The Arabic DASH questionnaire assessment of functional recovery found statistically significant difference between the level of upper limb capacity at the 3 months (28.4 ± 11.2) and the 6 months (19.1 ± 9.8) measurements ($p = 0.001$), showing an incremental increase in upper limb capacity with time. As expected, functional outcomes were strongly stratified with injury severity: patients with Gustilo IIIA injuries had a mean six-month DASH score of 14.3 ± 7.1 and an 84.1 percent return-to-work rate, compared with those with IIIC injuries having a mean score of 32.8 ± 12.6 with only 25.0 percent of occupational reintegration at six months (Table 4). Overall, 76 patients (67.9%) returned to their pre-injury vocation or main daily activities within 6 months. Satisfaction with the patient reports was high with 89.3% of patients reporting a satisfactory or highly satisfactory outcome regarding functional and aesthetic outcome at final follow-up.

Table 4. Functional Outcomes Stratified by Gustilo–Anderson Injury Grade (n = 112)

Gustilo–Anderson Grade	n	DASH Score at 6 months (mean ± SD)	Return to Work/Activity n (%)	Flap Survival n (%)
Type IIIA	44	14.3 ± 7.1	37 (84.1%)	43 (97.7%)
Type IIIB	56	21.5 ± 10.3	34 (60.7%)	50 (89.3%)
Type IIIC	12	32.8 ± 12.6	3 (25.0%)	9 (75.0%)
Total	**112**	**19.1 ± 9.8**	**76 (67.9%)**	**102 (91.1%)**

DASH = Disabilities of the Arm, Shoulder and Hand questionnaire; SD = standard deviation.

3.5 Resource Utilisation

The comparative analysis of local flaps (n = 112) with the free tissue transfer (n = 18, done within the framework of microsurgery pilot programme 2022) showed significant efficiency benefits of the former. Mean operative time decreased by 73.5 (102 ± 28 vs. 385 ± 62 minutes; $p < 0.001$). Local flap patients virtually did not have intensive care unit dependency (0.4 ± 0.6 vs. 3.2 ± 1.8 days; $p < 0.001$). According to the pricing parameters of the Iraqi Ministry of Health, 2022, per-case spending dropped by about 85 percent (420 vs. 2850; $p < 0.001$). The results are provided in Table 5.

Table 5. Comparative Resource Utilisation: Local Flaps vs. Free Flaps at GAHHSS (2022 Subgroup Analysis)

Parameter	Local Flaps (n=112)	Free Flaps (n=18)*	p value
Mean operative time (minutes)	102 ± 28	385 ± 62	<0.001
ICU stay (days, mean ± SD)	0.4 ± 0.6	3.2 ± 1.8	<0.001
Blood transfusion (units)	0.8 ± 1.1	2.3 ± 1.9	0.002
Hospital stay (days)	8.2 ± 2.4	14.7 ± 4.1	<0.001
Estimated cost per case (USD)†	$420	$2,850	<0.001
Surgeon requirement	1 plastic surgeon	2 microsurgeons + 1 assistant	—

* 2022 microsurgery pilot cohort (n = 18). † Estimated based on Iraqi Ministry of Health 2022 pricing guidelines (Ministry of Health, 2022). GAHHSS = Ghazi Al-Hariri Hospital for Surgical Specialties; ICU = intensive care unit.

Discussion

Understanding Flap Survival in the Hostile Wound Environment: 4.1 D. Konitz, 2009.

This 91.1% overall flap survival rate at the GAHHSS in seven years of uninterrupted practice is specifically remarkable since the wound environment in the case of blast injuries is hostile in its nature. These wounds are typified by the late onset, polymicrobial contamination, devascularised tissue margins and common bone and tendon loss - all known risk factors of compromised flaps. It is on par or better than published benchmarks of dedicated reconstructive programmes in high-income countries and with both local and free flap modalities (Al-Qattan, 2020; El-Shazly et al., 2021). This outcome seemed to be perpetuated by three institutional practices, namely; strict staged debridement with flap coverage not provided until the establishment of a clean granulating bed; a preference toward axial-pattern flaps with defined vascular territory (e.g., the DMA flap, 96.6% survival, and radial artery perforator flap, 100% survival); and the application of the standardised anatomical selection algorithm, which reduced variability due to individual surgeon preference (Girish et al., 2022).

The difference (relatively higher) in the complication rate between the PIA propeller flap (22.2% combined infection and partial necrosis) in this series is worthy of consideration. Although anatomically versatile and fully described in elective hand surgery, this flap is particularly vulnerable to venous outflow compromise in the oedematous contaminated periosteal milieu that is commonplace in blast wounds. Pre-flap elevation systematic Doppler mapping has now become standard practice at GAHHSS and has been linked with a decrease in flap-threatening complications since the practice started.

4.2 Functional Recovery: Functional Recovery over the Threshold of Survival.

Perhaps the greatest clinical outcome after upper limb reconstruction is purposeful functioning and not wound closure. The six-month DASH mean score of 19.1 among this cohort is associated with the level of moderate disability with retained independence in activities of daily living - a level that is allowing productive occupational participation in most manual and semi-skilled job descriptions (Hudak et al.,

1996). The six-month rate of 67.9% return-to-work is especially high in a culture where physical disability is directly and extensively converted into loss of income in the household and social marginalisation.

The significant difference in the results of Gustilo IIIA (DASH 14.3, return-to-work 84.1) and IIIC (DASH 32.8, return-to-work 25.0) outcomes is confirmation that reconstructive technique is able to optimise and not entirely neutralise the effect of devastating arterial and neurological injury. This finding has led to the revision of the protocol at GAHHSS whereby all IIIC injuries have been made to be subject to early vascular surgical consultation even in cases where definitive arterial repair is temporarily postponed due to wound maturation.

4.3 Local Flaps as Suitable Surgical Technology.

The Global Surgery 2030 report defined the disproportionately low- and middle-income countries as having the global unmet burden of surgical disease, and the need to invest in scalable, teachable, and affordable surgical technologies (Meara et al., 2015). An example of these principles is in the GAHHSS local flap programme. The 73.5% decrease in operative time relative to the free flap operations directly saves theatre capacity which is a key factor in determining the throughput of surgery at an institution dealing with more than 100 cases of blast limb reconstruction every year. The reduction of the elective ICU admission (0.4 vs. 3.2 days) allows spending the critical care resources on the life-threatening medical and traumatic emergencies. Limb salvage is cost reduction of 85 percent that makes it financially viable in the Iraqi health system which is publicly funded.

The comparative statistics do disprove the implicit belief that bigger defects (mean forearm defect 35.2 cm 2) are bound to necessitate free tissue transfer. Radiolateral forearm adipofascial flaps were able to mitigate the large flaws with a 90.9 percent survival, which is difficult to succeed when relying on international algorithmic thresholds which fail at free flaps larger than 20 of cm 2 (Sacks et al., 2018). This observation has direct implications to reconstructive surgeons who operate in austere settings in the world.

4.4 Regional and International Literature Comparison.

A similar series in Syria cited an 89 percent local flap survival of high-ranking extremity in blast wounds (Al-Hassan et al., 2022), and a Nigerian series of civilian trauma noted 93 percent success with similar techniques (Ogunleye et al., 2020). The current research contributes to the evidence base by offering flap-specific outcome data on the basis of which granular clinical decision making can be made, the valid functional metrics as opposed to survival as a single measure, and resource utilisation benchmarks of direct interest to the health policy planners in post-conflict environments. The Khoo et al. (2018) offer an in-depth anatomical basis of the upper extremity local flaps that support the anatomical reasoning behind the GAHHSS selection algorithm.

4.5 Limitations

There are a number of limitations that should be noted in the interpretation of these results. The retrospective design presents the risk of the selection bias and eliminates randomisation. The follow-up was only six months and this is not long enough to assess late complications, delayed functional deterioration or psychological sequellae of traumatic limb injury. Other measures of patient-reported outcomes such as health-related quality of life measures and ascertaining post-traumatic stress disorder were not administered systematically. Although protocol consistency is guaranteed, single-centre design restricts direct generalisability to smaller non-specialist hospitals operating in the district.

4.6 Policy and Educational Implications.

The proven effectiveness and efficiency of this programme has a number of implications on the development of the surgical system. In Iraq and other conflict-impacted countries, local flap vascular anatomy and operative technique should be considered a core competency in residency training in reconstructive surgery since it is better contextually relevant than microsurgical training. Pedicied local flaps should also be given formal national recognition as the reconstructive modality of first choice to be used to treat upper limb injuries in case of blast when there is no availability of free tissue transfer. International humanitarian surgical organisations must redefine their investment focus to sustainable capacity-building infrastructure (such as handheld Doppler equipments, hand therapies and standardised protocols) as opposed to importing technologically intensive models of microsurgery that are incapable of sustaining themselves.

Conclusion

This seven-year institutional series of Ghazi Al-Hariri Hospital Surgical Specialties illustrates that the use of pedicled local flaps, when used in the context of a standardised, anatomy-directed selection criteria, results in clinically significant flap survival, functional recovery, and patient satisfaction rates in patients sustaining upper limb injuries caused by a blast - even when there is no access to routine microsurgical facilities. The conclusive benefits in the area of operational efficiency, utilisation of critical care, and cost effectiveness determine that this method is not a trade-off, but the most suitable standard of care in relation to war trauma reconstruction in low-resource conditions. It is highly advisable to disseminate the institutional algorithm to regional trauma centres and to implement it into national surgical education programmes as a priority towards the recovery of the health system in post-conflict Iraq.

Declarations

Ethics Approval and Consent to Participate: The principles of the Declaration of Helsinki were followed, and the Research Ethics Committee of Baghdad Medical City gave its approval to the study (Reference: BMCREC-2024-017). The ethics board waived individual informed consent due to the anonymised and retrospective manner of data collection.

Conflict of Interest: The author states no conflict of interest.

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Data Availability: The de-identified data used to support the results of this study will be provided by the respective author upon reasonable request and under the approval of the institutional data governance.

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