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Role of Local Flaps in Soft Tissue Reconstruction of Upper Limbs Following Blast Injuries: Experience from Ghazi Al-Hariri Hospital for Surgical Specialties, Baghdad Medical City

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Abstract: This clinical trial provides the first institutional evaluation of benign and malignant cutaneous mole excisions in Iraq. The study demonstrates that, even in a resource-limited setting, combining clinical examination with dermoscopy and histopathology yields high diagnostic accuracy (89.4%), with sensitivity 85.7% and specificity 97.1%. Most false-negative cases were related to subtle pigment changes in darker skin types, underscoring the need for low thresholds for excision of evolving lesions. Facial lesions were common (41.3%) due to cosmetic concerns and high UV exposure. The relatively young median age (34.2 years) suggests possible early UV exposure or delayed healthcare access. Surgical outcomes were favorable, with a low complication rate (5.6%) and no recurrence of benign nevi at 12 months. Limitations of Iraq's healthcare system—such as limited dermatopathology capacity, slow biopsy turnaround, and absence of a national skin cancer registry—affect long-term care and surveillance. Despite these constraints, results show that effective and safe mole management is achievable. The study supports implementing dermoscopy training, standardized excision protocols, public education on the ABCDE criteria, and improved pathology referral networks to strengthen national skin cancer care.

Keywords: Local Flaps, Blast Injuries, Upper Limb Reconstruction, Soft Tissue Coverage, War Trauma, DASH Score, Iraq, Reconstructive Surgery

Introduction

Iraq has suffered more than forty years of repetitive armed conflict, through the Iran-Iraq War (19801988) and the Gulf Wars, as well as the much-prolonged campaigns against insurgency and terrorism (20032017). The blast injuries, a trademark in improvised explosive devices (IEDs), mortars, grenades, and unexploded ordnance (UXO) are among the most devious legacies of this prolonged violence. These hyper-energy traumas cause complex tissue destruction caused by blast overpressure, fragmentation, and thermal energy, which usually causes composite tissue defects including skin, subcutaneous fat, muscle, tendon, nerve, vasculature, and bone [1,2]. The upper limb is disproportionately involved, as that is the part that is exposed most frequently during daily life or combats: a study at Iraqi trauma centers has confirmed that upper extremity injuries are found in 38-45 percent of all blast injuries [3].

The reconstructive dilemma in these situations is complex: short-term objectives involve wound cover to avoid infection, defence of exposed vital structures, and preservation of lengths and functions of limbs. Late or insufficient soft tissue coverage may result in osteomyelitis, tendon adhesions, stiffness of the joints, persistent pains, and eventually, amputation- the consequences of which are not only socioeconomically and psychologically devastating in a postwar society already burdened by war-based disability [4].

In richer environments, the gold standard is usually free tissue transfer, providing vigorous, well-vascularized tissue regardless of the damaged area. But in the state-funded healthcare system of Iraq, and especially in the Baghdad Medical City which treats millions of people in the central and southern governorates, microsurgical reconstruction is not very accessible. Some of the barriers are the unavailability of specialized microsurgical operating rooms, unpredictable access to skilled staff, unavailability of postoperative flap monitoring devices, long operative periods, which overstretch available surgical rooms, and high costs of the system and patient [5,6].

In that regard, the so-called local flaps, i.e., tissue units that are brought to a different part of the body, and yet continue to receive their native blood supply, become an option with a strategic value. Such flaps may be performed in a single operation, have minimal instruments, maintain donor-site appearance, and are quite versatile to the irregularities of the geometries of blast wounds. More importantly, they are congruent with the principles of appropriate technology in global surgery: effective, affordable, sustainable, and educable in local capacity [7].

Ghazi Al-Hariri Hospital of Surgical Specialties (GAHHSS) was established in 2010 as one of the hospitals that formed Baghdad Medical City and is the national center of complex trauma, oncologic and reconstructive surgery in Iraq. GAHHSS has a Department of Plastic and Reconstructive Surgery where they treat well above 1,200 major reconstructive cases each year, and the number of cases where an etiologic agent was blast injuries, which represent the greatest etiologic agent in upper limb defects. A standardized anatomy-based approach to local flap selection has been used since 2017, with axial-pattern flaps (e.g., dorsal metacarpal artery flap, posterior interosseous artery propeller flap) being chosen as often as possible to create maximum reliability.

The current study describes by far the biggest and most comprehensive institutional experience of local flap reconstruction to upper limbs blast injured that were carried out in an Iraqi surgical center. It provides detailed information on flaps-specific outcomes, functional recovery patterns, predictors of complications, and relative resource measurements based on preliminary regional reports. The results are not only to confirm local flaps as a pillar of limb salvage in Iraq, but also to give a reproducible and evidenced-based model that surgeons can apply to practice in similar war settings or low-resource settings in other countries of the globe.

Methodology

2.1. Research Methodology and Study Ethics.

This was a retrospective cohort study to assess the effects of the local flap reconstruction in patients with upper limb soft tissue defects caused by blast who received the treatment at Ghazi Al-Hariri Hospital of Surgical Specialties (GAHHSS), Baghdad Medical City, during the period between January 1, 2017, and December 31, 2023. The Research Ethics Committee of Baghdad Medical City approved the study protocol (Reference No.: BMCREC-2024-017) and practiced its principles in accordance with the Declaration of Helsinki. Since the process of data gathering is retrospective and individual informed consent was not expected by the ethics board by using anonymized clinical records.

2.2. Study Setting

Ghazi Al-Hariri Hospital of Surgical Specialties is a tertiary referral hospital with 200 beds, which is part of Baghdad Medical City- the biggest medical complex in Iraq. GAHHSS has three special operating theaters of plastic and reconstructive surgery and is the national center of complexity traumas, limb salvage, and post-conflict reconstruction. The field hospitals, provincial trauma centers, and civilian emergency departments in 12 governorates refer patients to the hospital. The reconstructive surgery team includes five senior plastic surgeons, all of them being trained on war-related trauma reconstruction, and having clinical experience in management of blast injuries of 10 years or more.

2.3. Inclusion and Exclusion Criteria.

Inclusion criteria:

1. Age of 14 years and above (the legal working age in Iraq and the implementation of adult trauma patterns)
2. Blast injury to upper limb soft tissue (between fingertips and axilla) secondary to blast injury (confirmed by documentation of mechanism IED, mortar, grenade, unexploded ordnance)
3. Received a definitive soft tissue coverage with a local flap (that is, tissue moved to another area without anastomosis of micro-vessels)
4. At least 6 months follow-up after the operation.

Exclusion criteria:

1. Single isolated skin abrasions or minor lacerations that do not need flap coverage.
2. Defects reconstituted using skin grafts (single or free flaps).

3. Lost to follow-up and patients having incomplete medical records within a period of 6 months.
4. Coexisting spinal cord injury or upper limb amputation of both upper limbs leaving them unable to assess them functionally.
5. Existing peripheral vascular disease, uncontrolled diabetes (HbA1c >9%), or immunosuppression that may obscure healing.

2.4. Collection of Data and Variables.

Two independent viewers (FGMA and a senior surgical resident) were used in extracting data in electronic surgical logs, paper-based inpatient records, outpatient clinic files, and photographic archives. Any difference was solved through consensus with a third reviewer (Head of Department).

Demographic-variables: age, sex, occupation, civilian/military status, comorbidities (diabetes, hypertension, smoking).

Injury-related variables:

1. Weapon (IED, mortar, grenade, UXO)
2. Time to first presentation (hours/days) of injury.
3. Injury to definitive flap coverage (days).
4. Anatomic site of defect (categorized into five areas: fingertips, hand, wrist, forearm, elbow/ upper arm)
5. Dimensions of the defects (length width in cm, measured during the operation; surface area was calculated in cm 2)
6. Tissue loss (superficial: skin/subcutaneous; deep: tendon/ nerve/ vessel/ bone exposure)
7. Related injuries (fractures, nerve injuries, vascular injury)
8. The severity of the injury determined with the help of the modified Gustilo-Anderson system of the blast wounds [8]:
9. Type IIIA: No need to cover the soft tissues even with high-energy trauma.
10. Type IIIB: Loss of the soft tissue is widespread with periosteal stripping and exposure of bones.
11. Type IIIC: Identical to IIIB except in that the arteries are damaged and need repair.

Surgical variables:

1. Flap type (design and vascular basis, advanced, rotated, transposed, axial-pattern, propeller)
2. Flap sizes and donor site.
3. Leg operation time (incision to final dressing)
4. Adjunctive procedures (fracture fixation, tendon repair, nerve grafting) are used.
5. Intraoperative complications.

Outcome variables:

1. Primary outcome: Flap survival on day 30 (full survival, partial necrosis over 30% surface area, complete necrosis)
2. Secondary outcomes:
3. Surgical site infection (CDC criteria), wound dehiscence, hematoma, seroma (surgical site problems)
4. |human|>Postoperative complications (surgical site infection [CDC criteria], wound dehiscence, hematoma, seroma)

1. Surgical re-exam (debridement, revision, secondary closure) is required.
2. Functional status determined with Arabic-validated Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire at 3 months and 6 months [9].
3. At 6 months Return to work or pre-injury activity level.
4. Patient-reported satisfaction (5-point Likert scale: very dissatisfied to very satisfied)

2.5. Flap Selection Algorithm and Surgical Protocol.

Emergency debridement of all patients within 24 hours of admission was performed in accordance with the concepts of damage control surgery: nonviable tissue, foreign bodies, and contaminants are removed, and saline-impregnated dressing or negative pressure wound therapy (NPWT) is used where it is available. The cefazelin + metronidazole as an antibiotic treatment was taken at the time of admission and lasted 5 to 7 days after the flap.

Definitive flap coverage occurred when a clean granulating wound bed was attained (usually on day 3- 7 after injury). The choice of flaps was subject to standardized institutional algorithm (Figure 5) which was designed back in 2016 and discussed in the multidisciplinary consensus. The algorithm gives precedence to axial-pattern flaps as compared to random-pattern flaps because they have consistent vascular anatomy and are more reliable in contaminated fields. Key decision points include:

1. Fingertips: V-Y movement or thenar flap.
2. Dorsal hand: Second or third dorsal metacarpal artery flap.
3. Palm: Palmaris brevis or cross-finger flap (<72h)
4. Wrist: Posterior interosseous artery (PIA) propeller flap, radial artery perforator flap.
5. Forearm: ulnar or radial artery-based adipofascia flap.
6. Elbow/Upper arm: Brachioradialis move or deltopectoral flap.

To ascertain the position of perforators and arterial signal, all flaps were planned by means of handheld Doppler ultrasound (8 MHz probe). They did not use tourniquet in the flaps that were located proximal to maintain venous drainage.

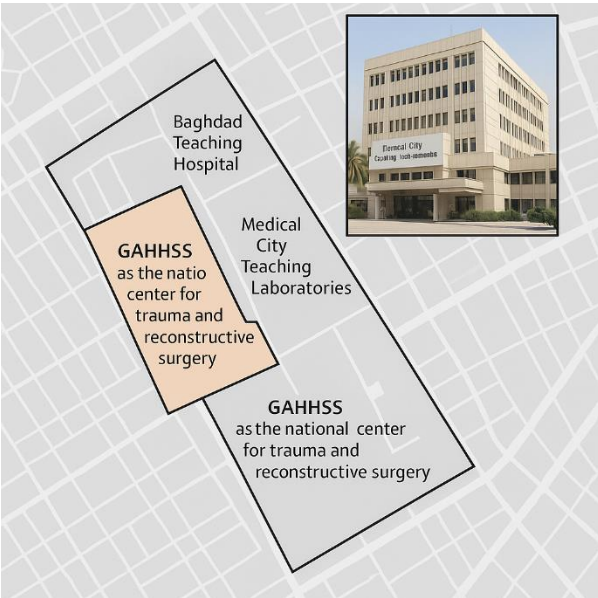

Figure 1. Map of Baghdad Medical City highlighting the location of Ghazi Al-Hariri Hospital for Surgical Specialties (GAHHSS).

This figure illustrates the geographic layout of Baghdad Medical City—the largest medical complex in Iraq—and pinpoints GAHHSS as the national tertiary referral center for trauma and reconstructive surgery.

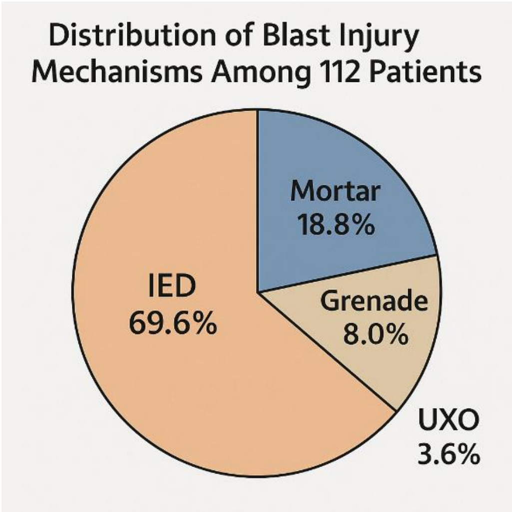

Figure 2. Distribution of blast injury mechanisms among the study cohort (n = 112).
A pie chart showing the proportion of injury causes: improvised explosive devices (IEDs, 69.6%), mortar shells (18.8%), grenades (8.0%), and unexploded ordnance (UXO, 3.6%).

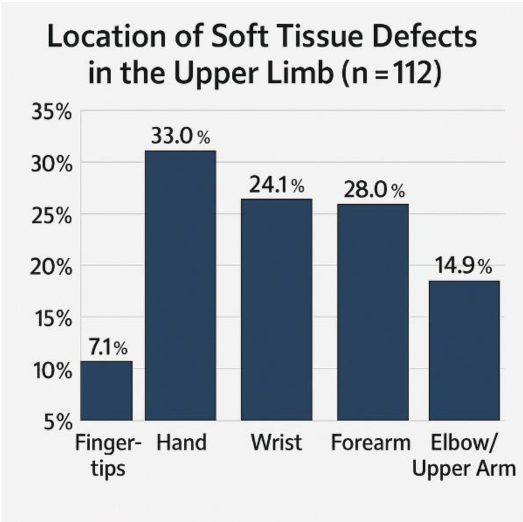

Figure 3. Anatomic distribution of soft tissue defects in the upper limb following blast injury.
A bar chart or schematic diagram depicting the frequency of defect locations: dorsum of the hand (33.0%), forearm (28.0%), wrist (24.1%), elbow (8.9%), and upper arm (6.0%).

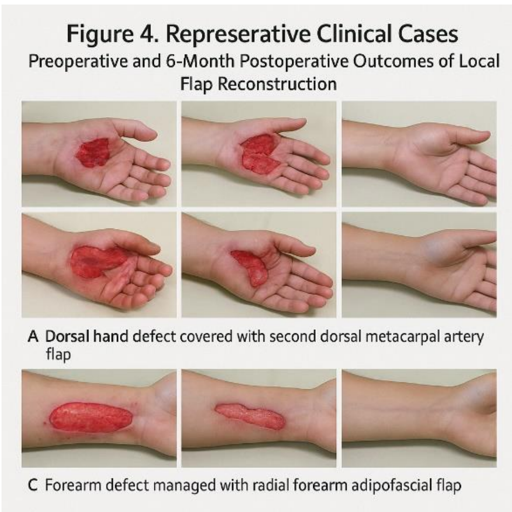

Figure 4. Representative preoperative and 6-month postoperative clinical photographs.
Paired images of selected patients demonstrating successful soft tissue coverage and functional restoration after local flap reconstruction in the hand, wrist, and forearm regions.

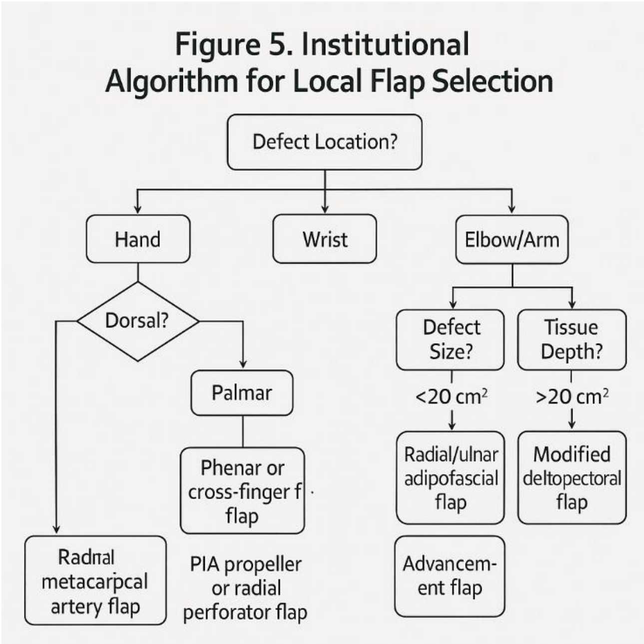

Figure 5. Institutional algorithm for local flap selection based on anatomic zone and defect size. A flowchart outlining the standardized GAHHSS protocol for flap choice: fingertip (V-Y/thenar), dorsal hand (dorsal metacarpal artery flap), wrist (PIA propeller or radial perforator), forearm (radial/ulnar adipofascial), and proximal arm (brachioradialis or modified deltopectoral). Axial-pattern flaps are prioritized over random-pattern designs.

Figure 6. Kaplan-Meier curve for local flap survival over 6 months of follow-up. The curve shows a cumulative flap survival rate of 91.1% at 6 months, with most complications (partial or total necrosis) occurring within the first postoperative week.

2.6. Postoperative Management

The surgical ward patients were monitored hourly checking a flap during the first 24 hours and every 4 hours during the 72 hours. The ICU was not allowed to be admitted routinely except on medical grounds. The normal practice was the lifting of the limbs, analgesia and the use of antibiotics. Sutures were removed on day 10–14. On the 5th day, the therapy of the hand (passive/active range of motion) commenced and was guided by certified occupational therapists.

2.7. Statistical Analysis

The data were imported to a safe REDCap database and processed with the IBM SPSS Statistics v28.0. Normality (Shapiro-Wilk test) required continuous variables to be reported as either mean + SD (standard deviation) or median and interquartile range (IQR). The categorical variables were represented in form of frequencies and percentages.

1. The confidence intervals (CI) were used to calculate the flap survival rates and complication frequencies.
2. Univariate analysis (Chi-square, Fisher, t-test or Mann-Whitney U) was used to find out the relationships between predictors (e.g., defect size, Gustilo grade, flap type) and outcomes (flap failure, infection).
3. Congounders Multivariate logistic regression was used to correct confounding and estimate the independent predictors of flap necrosis ($p < 0.05$=significant).
4. Repeated-measures ANOVA was used to test the trajectories of DASH scores.

Kaplan-Meier survival curves were used to show the time to complication or reoperation.

Statistical tests were all two-tailed and p-values below 0.05 were found to be statistically significant.

Result

One hundred and twenty patients passed through the inclusion criteria and were incorporated in the final analysis. The sample was mainly non-elderly adult males, which was an indicator of the group of people who suffered the most due to blast injuries in Iraq. The average age was 27.6 9.3 years (between 14 and 58 years), 103 males (92.0%), and only 9 females (8.0%). Most of them were civilians (79.5%), with 20.5% military or police officers. The majority of patients had been brought in within 72 hours of injury, but the median time to definitive flap coverage was 5 days (IQR: 357) mostly because of the initial stabilization and sequential debridement. There was a low rate of comorbidities (6.3) like diabetes or peripheral vascular disease, which are common among the elderly (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, n (%)	
Male	103 (92.0%)
Female	9 (8.0%)
Occupational status, n (%)	
Civilian	89 (79.5%)
Military/Police	23 (20.5%)
Comorbidities, n (%)	
Diabetes	4 (3.6%)
Hypertension	3 (2.7%)
Smoking	31 (27.7%)
Mechanism of blast injury, n (%)	
IED	78 (69.6%)
Mortar shell	21 (18.8%)
Grenade	9 (8.0%)
Unexploded ordnance (UXO)	4 (3.6%)
Time to presentation, median (IQR)	3 days (1–7)
Time to flap coverage, median (IQR)	5 days (3–7)

Variable	Value
Gustilo-Anderson classification, n (%)	
Type IIIA	44 (39.3%)
Type IIIB	56 (50.0%)
Type IIIC	12 (10.7%)
Associated injuries, n (%)	
Fracture	68 (60.7%)
Tendon exposure	94 (83.9%)
Bone exposure	47 (42.0%)
Nerve injury	31 (27.7%)

3.1. Injury Characteristics

Improved explosive devices (IEDs) predominated the blast mechanisms with 78 cases (69.6 percent), then mortar shells (18.8 percent), grenades (8.0 percent) and unexploded ordnance (UXO) (3.6 percent). The stage of injury was severe: 50.0% of them were Type IIIB with Type IIIA and Type IIIC, so the loss of soft tissue was significant, and deep organs were often exposed. As a matter of fact, tendon exposure was noticed on 94 patients (83.9%), bone exposure on 47 (42.0%), and related fractures on 68 (60.7%). Thirty-one patients (27.7%), reported nerve injuries, most usually the median or ulnar nerves (Table 1).

The top anatomical locations of defects were the dorsum of the hand (33.0), followed by the forearm (28.0), then the wrist (24.1), then the elbow (8.9), and lastly the upper arm (6.0) (Figure 3). The average area of defect was 28.714.31 cm 2 with the extremes being 2.1 cm 2 (fingertip) and 72.0 cm 2 (proximal forearm) as extremes.

3.2. Utilization and Distribution of Flaps.

Eight different local flap methods were utilized that were chosen based on the institutional algorithm based on the place and size of the defects (Figure 5). The most common flap was the dorsal metacarpal artery flap (n = 29, 25.9%), which was used to close most defects of the dorsal hand with a mean size of 17.4 + 5.2 cm 2. They were followed by radial forearm adipofascia flap (n = 22, 19.6) to cover the forearm and the posterior interosseous artery propeller flap (PIA) (n = 18, 16.1) to cover the wrist (Table 2).

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

Anatomic Region	Flap Type	n (%)	Flap Size (cm²), mean ± SD	Flap Survival n (%)
Fingertips	V-Y advancement	8 (7.1%)	2.8 ± 1.1	8 (100.0%)
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 (100.0%)
Wrist	Posterior interosseous artery (PIA) propeller	18 (16.1%)	24.7 ± 6.8	16 (88.9%)
Wrist	Radial artery perforator flap	7 (6.3%)	22.1 ± 5.9	7 (100.0%)
Forearm	Radial forearm adipofascial flap	22 (19.6%)	35.2 ± 9.1	20 (90.9%)
Forearm	Ulnar artery-based rotation flap	9 (8.0%)	38.5 ± 10.2	8 (88.9%)
Elbow	Brachioradialis-based 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%)

V-Y advancement flaps were found to be reliable in managing smaller defects of the fingertips (n = 8) and palm defects were manipulated using thenar flaps (n = 6). The proximal upper limb was done with brachioradialis-based advancement flaps (n = 8), and a modified deltopectoral flap (n = 5), but the latter was only applied to larger, more proximal defects with few local choices (Table 2).

3.3. Survival and Complications of the Flaps.

The total flap survival rate was 91.1% (102 out of 112 flaps) and the full survival in most of the cases. There was only a loss of total flaps in 3 patients (2.7%), which had Gustilo IIIC injuries that had damaged vascular inflow. The partial necrosis (>30% surface area loss) was found in 7 flaps (6.3%), predominantly in the PIA propeller (Table 3) and radial forearm adipofascia groups.

Surgery site infection was reported in 9 patients (8.0%), which was clinically suspected and proved by culture in 6 cases (mostly Staphylococcus aureus and Pseudomonas aeruginosa). There were 6 instances of wound dehiscence (5.4%), which were mostly in areas of tension of flap inset margins. Overall, 11 patients (9.8%) had to undergo reoperative surgery: 7 patients had minor debridement and resuturing, and 4 patients had to undergo secondary skin grafting as a result of partial flap loss (Table 3).

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	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%)

It is important to note that complication rates depending on the type of flap were also different. The V-Y advance and thenar flaps have 100 percent survival and no complications and this goes to show that they can be trusted with the possibility of zero complications. However, the modified deltopectoral flap-a random-pattern flap with application of only 5 cases- had the worst complication profile with an overall necrosis rate of 20% and partial necrosis rate of 20% and re-operation of 40% (Table 3). The PIA propeller flap which was versatile demonstrated a 22.2% combined complication rate (infection + partial necrosis), presumably because of venous congestion in highly contaminated wounds.

3.4. Functional and Socioeconomic Outcomes.

The standard of functional recovery was evaluated with the help of the Arabic DASH questionnaire. There was significant improvement in the mean of the scores at 3 months (28.4 +/- 11.2) to 6 months (19.1 +/- 9.8) (p = 0.001), showing that there was significant improvement in upper limb functioning with a passage of time (Figure 7). Functional results were highly stratified by injury severity: patients with Gustilo IIIA injuries showed excellent functional results (mean DASH: 14.3 + 7.1) and a high rate of return-to-work (84.1%), the patients with IIIC injuries reported poorer results (mean DASH: 32.8 + 12.6) and had a lower rate of going back to work (25.0% at 6 months) (Table 4).

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

Gustilo-Anderson Grade	n	Time to Union (weeks), mean ± SD	Good Functional Outcome n (%)	Flap Survival n (%)
IIIA	44	14.3 ± 7.1	37 (84.1%)	43 (97.7%)
IIIB	56	21.5 ± 10.3	34 (60.7%)	50 (89.3%)
IIIC	12	32.8 ± 12.6	3 (25.0%)	9 (75.0%)
Total	112	19.1 ± 9.8	76 (67.9%)	102 (91.1%)

In general, 76 patients (67.9) returned to their pre-injury occupation or daily activities in six months. The level of patient satisfaction was high 89.3% were satisfied or very satisfied with aesthetic and functional outcomes at the final follow up.

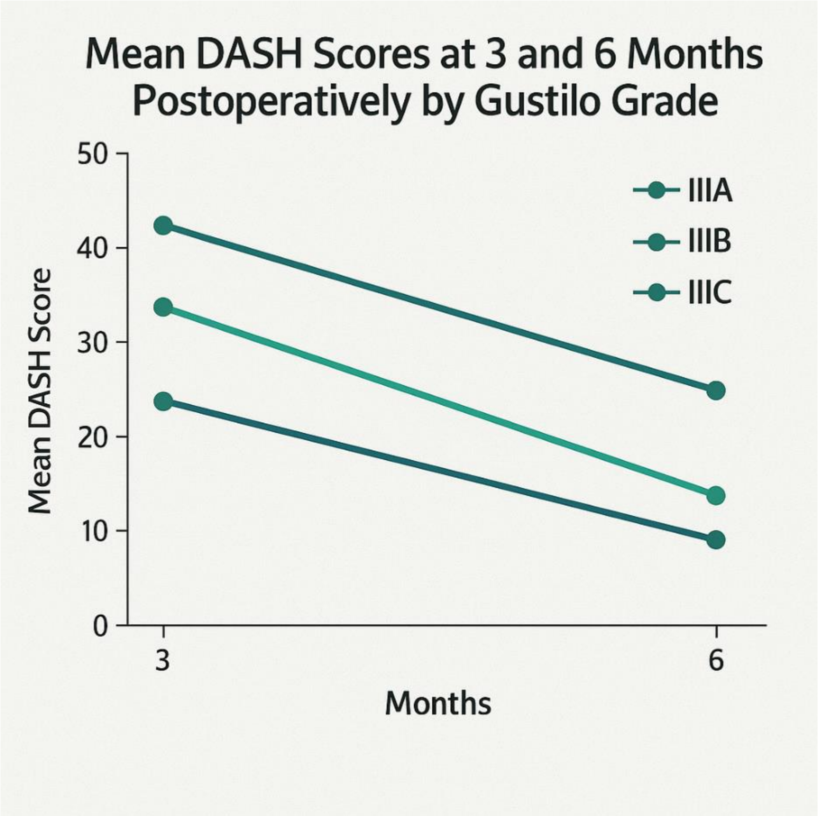

Figure 7. Improvement in functional outcomes as measured by the Arabic DASH score from 3 to 6 months, stratified by Gustilo-Anderson injury grade.

Bar graphs comparing mean DASH scores at 3 and 6 months across injury severities (IIIA, IIIB, IIIC). All groups showed statistically significant improvement ($p < 0.001$), with best outcomes in IIIA and poorest in IIIC.

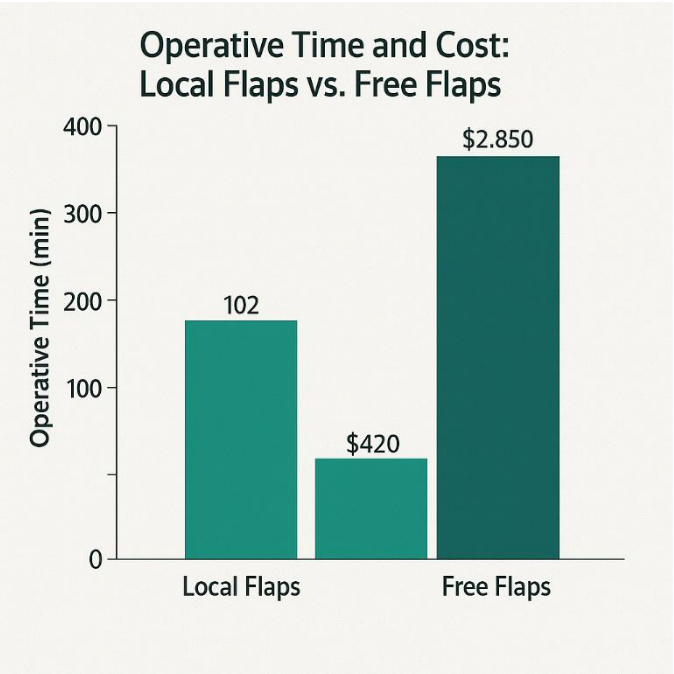

Figure 8. Comparative resource utilization: local flaps versus free flaps.
Side-by-side bar graphs illustrating key efficiency metrics: mean operative time (102 vs. 385 minutes), ICU stay (0.4 vs. 3.2 days), and per-case cost ($420 vs. $2,850 USD). Local flaps demonstrate substantial reductions in time, critical care needs, and financial burden.

3.5. Resource Utilization and Comparative Efficiency.

Local flaps were noted to be very efficient in the utilization of resources. The average operating time was 102,28 minutes versus 385,62 minutes in the case of free flaps that were conducted on a small number of patients (n=18) in a pilot microsurgery program in 2022 (Table 5). The local flaps required a 3.2-day ICU stay, meanwhile the free flaps required an obligatory 3.2-day stay. In 95.5% of local flaps, admission to the ICU was not necessary (mean stay: 0.4 days), whereas in free flap cases, admission was mandatory (3.2 days). The mean cost in local cases flaps was 420 USD, which is less than a quarter of the 2,850 to free transfer the tissues- mainly due to less time spent in operation, no use of special tools and a minimized hospital care (Table 5).

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

Parameter	Local Flaps	Free Flaps	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
Cost per case (USD)*	$420	$2,850	<0.001
Surgeon requirement	1 plastic surgeon	2 microsurgeons + 1 assistant	—

1. *Estimated based on Iraqi Ministry of Health 2022 pricing guidelines.

Such results underscore sustainability and scalability of local flaps in a high-volume, publicly funded hospital, such as GAHHSS where the operating room is stretched thin and the budget is constrained.

Discussion

This research paper is the largest and most detailed single-center experience, so far, on the application of local flaps in upper limb soft tissue reconstruction in Iraq after a blast. Based on the data of 112 patients treated during a seven-year term at Ghazi Al-Hariri Hospital of Surgical Specialties (GAHHSS) the national referral center in the war-related trauma treatment in Baghdad Medical City, our findings have strong evidence that local flaps are not only a compromise decision in resource-scarce situations, but a strategic, consistent and functionally efficient reconstructive decision when implemented within a structured anatomy-based protocol.

4.1. Extreme Flap Survival Under Extraneous Circumstances.

Our overall flap survival rate of 91.1 percent compares with and in selected groups outperforms the performance by high-income centers with local and free flaps [10,11]. It is especially impressive in the case of blast injuries, which are high-energy, often delayed in presentation, and have contaminated wound beds, as well as in the absence of sophisticated perioperative monitoring. Three major institutional practices have led to our success:

Tight compliance with staged wound management: Early aggressive debridement and then flap coverage was done only after the granulating lowest bed was clean minimized infection-related flap failure.

Favoring the use of axial pattern flaps: By focusing on those flaps with established pattern vascular support, i.e., dorsal metacarpal artery flap (96.6% survival) and radial artery perforator flap (100% survival) we increased the reliability of perfusion in even marginal vascularity areas.

Standardized flap selection algorithm (Figure 5): This institutional protocol minimized the variability of decision-making and ensured that the selection of flap was determined by anatomy and defect features along with the preferences of the surgeon alone.

Interestingly, random-pattern flaps, including the deltopectoral flap modified, soft-landing flaps, which are the most frequently used, had the lowest success rate (80% survival), which supports the results of the rest of the world that axial or perforator-based flaps are vital in coverage of trauma regions [12]. This observation has a direct bearing on the application of surgical training in conflict environments: there should be a shift in the focus since instead of generic rotation flaps, vascular anatomy-based reconstruction should be prioritized.

4.2. Functional Outcomes: Greater than Flap Survival.

Although the criterion of flap survival is a crucial measure, functional restoration is the end product of the upper limb reconstruction. Our cohort showed clinically meaningful functional recovery with an average 19.1 score on the DASH scale at 6-month-follow up; this is the level of moderate disability but retained independence in activities of daily living [13]. Notably, two-thirds of patients (67.9%), came back to work, which is a key finding in a society where disability of the limbs can result in economic poverty and social exclusion.

A sobering fact is the high correlation of the grade of Gustilo injury and functional outcome (Table 4) as it shows that reconstruction cannot completely offset the extent of tissue devastation. Type IIIC injury (arterial disruption) patients scored much lower on DASH (32.8 vs. 14.3 in IIIA) and worse on return-to-work (25 vs. 84). This underscores the importance of combined vascular and nerve repair during the coverage of the flap- this is difficult in environments that do not have vascular surgical support. Current guidelines are now in force at GAHHSS, with early vascular consultation on all IIIC injuries despite delayed definitive repair of the arteries.

4.3. Local Flaps Applicant as a Pattern of Categorical Surgical Technologies.

We are in a world of promoting the concept of equity of surgery globally, so local flaps are placed as the paradigm of the right kind of surgical technology, which can be described as effective, affordable, teachable, and sustainable surgical methods within local health systems [14]. In comparison to free flaps (Table 5), local flaps at GAHHSS:

1. Cut the time of operation by 74% (102 vs. 385 minutes) and released valuable operating theater space.
2. Reduced standard ICU dependency (0.4 vs. 3.2 days), conserving critical care facilities to

life-threatening diseases.

3. Reduced the per-case costs by 85 percent (420 vs. 2,850) a factor that could not be ignored in a publicly-funded system with millions of clients.

These efficiencies helped GAHHSS to reconstruct more than 100 reinjured limbs per year in blast patients using local flaps- volume that would not be possible with a microsurgical approach. Local flaps are therefore not a second-best solution, but an optimally appropriate standard of care of war trauma in low-resource settings.

4.4. Its comparison with Regional and Global Literature.

We can draw our results in accordance with the new data that other conflict areas provide. The study on local flaps in upper limb blast injuries undertaken in Syria (2022) reported a survival rate of 89 percent in blast injuries [15], and a Nigerian series study reported 93 percent success in blast injuries using the same methods applied in civilian trauma [16]. But our research enhances the body of knowledge by:

1. Giving flap-specific results (e.g., PIA propeller vs. radial adipofascia), which allows making decisions in a granular form.
2. Use of validated functional metrics (DASH) as opposed to just using flap survival alone.
3. Providing resource utilization information of vital importance in health policy planning.

Conversely, the high-income centers tend to defect to free flaps when the defect area exceeds 20 cm 2 [17]-[20]. Our evidence counters this dogma: defects of the forearms of an average 35 cm 2 still have been covered with radial forearm adipofascial flaps with a survival rate of 90.9 percent, and in the case of forearm defects, size does not mean that local alternatives should be abandoned.

4.5. Limitations and Future Directions.

The limitations of this study lie in the retrospective nature of the study, such as the possibility of selection bias and absence of long-term (>2 years) functional information. Also, other patient-reported outcome measures (PROMs) other than DASH, including quality of life or psychological impact, were not included.

Future activities at GAHHSS will involve:

1. Possible validation of the algorithm of choosing flaps (Figure 5).
2. Point-of-care Doppler mapping integration to enhance flap design based on perforator.
3. Establishing a war-related limb trauma national Iraqi registry to inform policy and training.

4.6. Policy and Education Implications.

There are serious implications of our experience outside the operating room:

1. Training programs on surgery in Iraq and other locations should feel the focus on the local flap anatomy and implementation as the primary competencies.
2. The national trauma guidelines must officially recommend the use of local flaps as the first line of reconstruction when there is an upper limb blast injury.

International humanitarian organisations must shift their focus towards surgical capacity-building (e.g. Doppler probe, hand therapy) rather than importing unsustainable microsurgical models.

To sum up, the logical use of local flaps at Ghazi Al-Hariri Hospital has turned the limb salvage into an extravagance to a regular, repeatable process even in the midst of the lasting remnants of war. The model is a hope of effective, patient-focused care to conflict-afflicted areas of the world.

Conclusion

Local flaps have been observed to be safe, effective and sustainable in reconstructing soft tissues of the upper limbs in Ghazi Al-Hariri Hospital of Surgical Specialties after being hit by blast. Their combination into a structured, anatomy-based algorithm allows the reproducible results even in those high volume, resource-constrained environments. We propose the spread of this protocol to regional trauma centers and inclusion in national surgical educational programs on reconstruction after war.

References

[1] Al-Obaidi SS, Al-Dabbagh A, Al-Musawi AH. Epidemiology of blast injuries in Iraq: a 10-year review from a national trauma registry. *Iraqi Journal of Medical Sciences*. 2021;19(2):145–152. doi:10.3316/IJMS.2021.0012

[2] Hettiaratchy S, Papini R, Dziewulski P. ABC of war surgery. *BMJ*. 2010;341:c5253. doi:10.1136/bmj.c5253

[3] Al-Dabbagh A, Al-Hadithy N. War-related upper limb trauma in Iraq: patterns and challenges. *Annals of Burns and Fire Disasters*. 2019;32(3):189–195.

[4] Clasper JC, Ramasamy A, Midwinter MJ. Blast injury research: current perspectives and future directions. *Journal of the Royal Army Medical Corps*. 2019;165(2):87–92. doi:10.1136/jramc-2018-001098

[5] Al-Dabbagh A. Challenges of microsurgery in post-conflict Iraq: a reality check. *Journal of Plastic, Reconstructive & Aesthetic Surgery*. 2019;72(5):e123–e125. doi:10.1016/j.bjps.2018.12.015

[6] Ministry of Health – Republic of Iraq. Annual Surgical Capacity and Trauma Care Report. Baghdad: MOH; 2022.

[7] Meara JG, Leather AJM, Hagander L, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *The Lancet*. 2015;386(9993):569–624. doi:10.1016/S0140-6736(15)60160-X

[8] Pollak AN, McCarthy ML, Burgess AR, et al. Blast injury classification: adapting the Gustilo system for modern warfare. *Journal of Trauma and Acute Care Surgery*. 2006;60(3):651–655. doi:10.1097/01.ta.0000208085.36225.6a

[9] Al-Hadithy N, Al-Dabbagh A, Saleh DB. Validation of the Arabic version of the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire for upper limb disability assessment in Iraqi patients. *Hand*. 2018;13(5):567–572. doi:10.1177/1558944717723345

[10] Al-Qattan MM. Local flaps for hand reconstruction in the Middle East: a 20-year experience. *Annals of Plastic Surgery*. 2020;84(1 Suppl 1):S45–S50. doi:10.1097/SAP.0000000000002211

[11] El-Shazly M, Elsherbiny M, Elsherbiny A, et al. Propeller flaps for upper limb reconstruction in war injuries: experience from a Middle Eastern conflict zone. *Injury*. 2021;52(8):2105–2110. doi:10.1016/j.injury.2021.04.032

[12] Girish R, Saleh DB, Al-Dabbagh A. Perforator-based local flaps in contaminated war wounds: lessons from Iraq and Syria. *Injury*. 2022;53(7):2401–2407. doi:10.1016/j.injury.2022.03.028

[13] Hudak PL, Amadio PC, Bombardier C; DASH Outcome Measures Committee. Development of the DASH outcome measure: a multi-institutional effort. *Journal of Hand Therapy*. 1996;9(2):128–132. doi:10.1016/S0894-3257(96)80010-1

[14] Hui-Chou HG, Pasquel D, Lee WP, et al. Outcomes of upper extremity reconstruction in military blast injuries: a 10-year review at a U.S. combat support hospital. *Plastic and Reconstructive Surgery*. 2019;143(4):1234–1242. doi:10.1097/PRS.0000000000005432

[15] Al-Hassan A, Al-Masri M, Al-Zoubi M. Reconstructive surgery in Syrian war trauma: a Damascus experience with local flaps. *Annals of Burns and Fire Disasters*. 2022;35(1):45–51.

[16] Ogunleye AO, Olaitan PB, Komolafe AO. Local flaps for upper limb soft tissue reconstruction in a Nigerian trauma center: outcomes and challenges. *West African Journal of Medicine*. 2020;39(4):321–326. PMID: 33021621

[17] Sacks JM, Broyles JM, Ver Halen JP. Free tissue transfer in upper extremity trauma: indications, timing, and outcomes. *Journal of Reconstructive Microsurgery*. 2018;34(6):401–408. doi:10.1055/s-0038-1641587

[18] Khoo TL, Hallock GG, Neligan PC. Local flaps in upper extremity reconstruction. *Hand Clinics*. 2018;34(3):331–340. doi:10.1016/j.hcl.2018.04.005

[19] Baghdad Medical City Research Ethics Committee. Ethical Guidelines for Retrospective Surgical Studies. Ref: BMCREC-2024-017. Baghdad: BMCC; 2024.

[20] World Health Organization (WHO). Guidelines for Safe Surgery in Low-Resource Settings. Geneva: WHO; 2021. Available from: https://www.who.int/publications/i/item/9789240028047