

Machine-cut Upper Limb Vascular Injuries in Agricultural Workers: A Case Series

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ABSTRACT

Agricultural machinery-related vascular injuries represent a severe occupational hazard with potential for permanent disability and limb loss. A case series of seven consecutive patients with upper limb vascular injuries from agricultural machinery was included. All seven patients (100% male, mean age 42±8 years) presented with combined neurovascular injuries. Brachial artery involvement occurred in 85.7% (6/7) of cases with universal median nerve injury. Hay balers were the most common causative machinery (42.9%), followed by rice harvesters (28.6%). Interpositional vein grafting was required in 71.4% (5/7) of cases. Despite delayed presentation and injury severity (71.4% with sensorimotor deficits), 100% limb salvage was achieved with restoration of arterial flow in all patients. Complex agricultural machine-cut injuries involving major upper limb vessels demonstrate excellent limb salvage outcomes when managed at specialised vascular centres, even with delayed presentation up to 24 hours. The high prevalence of preventable human and mechanical factors underscores the urgent need for mandatory safety training and equipment modification in agricultural settings.

Keywords: Agricultural injury, Brachial artery injury, Interpositional grafting, Limb salvage, Machine-cut injury, Occupational safety, Vascular trauma

INTRODUCTION

Occupational injuries constitute a critical yet under-recognised global public health crisis, with an estimated 100 million cases occurring annually worldwide [1]. Farm injury patterns are severe but the machines causing injuries differ because mechanisation levels differ in different countries [2]. According to the Bureau of Labour Statistics (BLS), there were a total of 422 workers who died in the agricultural production sector in 2007, for an annual fatality rate of 24.2 deaths per 100,000 workers [3]. A systematic review identifies significant risk factors for agricultural injury based on the literature. The pooled ORs for the risk factors were as follows: male gender (vs. female) 1.68, full-time farmer (vs. part-time) 2.17, owner/operator (vs. family member or hired worker) 1.64, regular medication use (vs. no regular medication use) 1.57, prior injury (vs. no prior injury) 1.75, health problems (vs. no health problems) 1.21, stress or depression (vs. no stress or depression) 1.86, and hearing loss (vs. no hearing loss) 2.01 [4].

CASE SERIES

This case series was conducted at the Emergency Medical Services Department of a tertiary referral centre in Puducherry, India, from January 1, 2023, to June 30, 2025. It included adult patients (≥18 years) presenting with acute vascular injury to the upper limb, specifically those who sustained injuries from agricultural machinery during occupational activities, had vascular injury confirmed by clinical examination and/or imaging, and underwent surgical intervention at our institution.

Seven patients met the inclusion criteria. Hay balers were the most frequently implicated machinery (42.9%, 3/7 cases), followed by rice harvesters (28.6%, 2/7), grain augers (14.3%, 1/7), and wheat threshers (14.3%, 1/7) [Table/Fig-1,2].

Vascular injuries: The brachial artery was involved in 85.7% (6/7) of cases, representing the predominant site of major vessel injury. The remaining case involved combined radial and ulnar artery injuries at the forearm level [Table/Fig-3a-c]. No patients presented with isolated venous injuries; all arterial injuries had concurrent venous involvement requiring repair.

Neurological injuries (n=7, 100% median nerve involvement): Median nerve injury was universally present (100%, 7/7 cases). Associated

Characteristic	n (%) or Mean±SD
Age (years)	42±8
Male sex	7 (100%)
Brachial artery injury	6 (85.7%)
Median nerve injury	7 (100%)
Sensorimotor deficit at presentation	5 (71.4%)
Associated biceps injury	4 (57.1%)
Associated fracture	1 (14.3%)

[Table/Fig-1]: Patient demographics and injury characteristics (n=7). SD: Standard deviation. Data are presented as n (%) or mean±SD. This table summarises the demographic and injury profiles of all seven patients included in the case series (see Case Series section)

Case	Age/sex	Time to presentation (hrs)	Machine involved	Major arterial injury	Venous injury	Nerve injury	Musculoskeletal injury
1	39/M	3	Hay balers	Brachial artery injury	Minor	Median nerve injury	Biceps muscle
2	35/M	7	Grain augers	Brachial and ulnar and radial injury	Minor	Median nerve injury	Brachioradialis
3	42/M	6	Hay balers	Radial and ulnar injury	Minor	Median nerve injury	Biceps muscle
4	31/M	4	Wheat harvesters	Brachial artery injury	Minor	Median nerve injury	Biceps muscle
5	45/M	2	Rice harvesters	Brachial artery injury	Minor	Median nerve injury	-
6	32/M	1 hour 30 mins	Hay balers	Brachial artery injury	Minor	Median nerve injury	Biceps muscle
7	38/M	5	Rice harvesters	Brachial artery injury	Minor	Median nerve injury	-

[Table/Fig-2]: Individual case profiles of all seven patients.



[Table/Fig-3]: a) Preoperative view showing radial artery injury with associated soft-tissue damage; b) preoperative view showing brachial artery injury with associated soft-tissue damage; c) Image showing ulnar artery and median nerve injury.

sensorimotor deficits at presentation included: loss of thumb opposition and abduction (71.4%, 5/7), impaired wrist and finger flexion (71.4%, 5/7), sensory deficit in the median nerve distribution (100%, 7/7), and claw-hand deformity in severe cases (28.6%, 2/7). Overall, 71.4% (5/7) of patients demonstrated significant sensorimotor compromise at presentation [Table/Fig-4].

Human factors were identified in all cases and included operator fatigue from prolonged work shifts (57.1%, 4/7). Mechanical and environmental deficiencies were equally prominent: absent or non-functional safety guards were documented in 85.7% (6/7) of cases [Table/Fig-5].

Vascular reconstruction techniques: All patients underwent emergency vascular repair following resuscitation. Interpositional vein grafting (reverse saphenous vein) was required in 71.4% (5/7) due to tissue loss precluding tension-free anastomosis; primary end-to-end anastomosis was feasible in 28.6% (2/7) [Table/Fig-6]. A100% (7/7) limb salvage was achieved. No patients required major amputation (above wrist level) during hospitalisation or at discharge.

Vascular patency: Successful restoration of distal arterial pulses was documented in all patients (100%, 7/7) immediately postoperatively and maintained at discharge. No cases of graft thrombosis or acute re-occlusion occurred during hospitalisation.

Functional outcomes at discharge: At discharge, sensory recovery in the median nerve distribution was complete or near-complete in 28.6% (2/7) of patients, while the remaining 71.4% (5/7) demonstrated partial recovery with diminished two-point discrimination. Motor recovery sufficient for basic activities of daily living was achieved in 85.7% (6/7), with 71.4% (5/7) retaining only a minimal residual deficit at grade 4/5 strength. Overall, 85.7% (6/7) attained functional status adequate for return to modified agricultural work at the time of discharge.



[Table/Fig-4]: a) Patient with right brachial artery with median nerve injury and distal humerus fracture; b) Intra-op Images after brachial artery reconstruction with SVG graft and median nerve primary repair with SSG skin graft and external fixation; c) Post-op 7th day image.

Category	Factor	n (%)
Machinery	Hay baler	3 (42.9%)
	Rice harvester	2 (28.6%)
	Grain auger	1 (14.3%)
	Wheat harvester	1 (14.3%)
Human factors	Operator fatigue	4 (57.1%)
	Distraction	3 (42.9%)
	Sleep deprivation	3 (42.9%)
	Poor concentration	4 (57.1%)
Mechanical factors	Absent/non-functional safety guards	6 (85.7%)
	Non-use of protective equipment	6 (85.7%)
	Poor machine maintenance	3 (42.9%)
	Inaccessible emergency shut-off	5 (71.4%)
	Inadequate operator training	4 (57.1%)

[Table/Fig-5]: Machinery types and risk factors.
M: Male; hrs: Hours; RSVG: Reverse saphenous vein graft

Complications: No perioperative mortality occurred. Minor wound complications (superficial infections) occurred in 14.3% (1/7) and were managed with antibiotics and local wound care. No major complications (deep infection, sepsis, graft failure) were observed. Median length of stay was 12 days (range: 8-18 days). Representative cases are shown in the [Table/Fig-7,8].

DISCUSSION

This case series provides important insights into the clinical characteristics, management, and outcomes of severe agricultural machine-cut vascular injuries in South India.

Grandizio LC et al., reported that 96 of 273 patients (35%) sustained an upper extremity injury with fractures of the phalanx and radius/ulna occurring most frequently [5].

Case	Age/sex	Surgical procedure	Operative time	Limb salvage	Pulse at discharge	Sensory recovery (at the time of discharge)	Motor recovery (at the time of discharge)	Complications
1	39/M	Primary vascular resection and anastomosis	3.5 h	Yes	Radial and ulnar palpable	Complete recovery	Sufficient recovery	Nil
2	35/M	RSVG interpositional grafting	6 h	Yes	Radial and ulnar palpable	Partial recovery	Sufficient recovery	Nil
3	42/M	RSVG interpositional grafting	5 h	Yes	Radial and ulnar palpable	Partial recovery	Partial recovery	Nil
4	31/M	RSVG interpositional grafting	3.5 h	Yes	Radial and ulnar palpable	Partial recovery	Sufficient recovery	Nil
5	45/M	RSVG interpositional grafting	3.5 h	Yes	Radial and ulnar palpable	Partial recovery	Sufficient recovery	Surgical site infection
6	32/M	RSVG interpositional grafting	4.5 h	Yes	Radial and ulnar palpable	Complete recovery	Sufficient recovery	Nil
7	38/M	Primary vascular resection and anastomosis	4 h	Yes	Radial and ulnar palpable	Partial recovery	Sufficient recovery	Nil

[Table/Fig-6]: Surgical procedures and clinical outcomes for each of the seven patients.
M: Male; RSVG: Reverse saphenous vein graft; hrs: Hours



[Table/Fig-7]: Clinical presentation and postoperative outcome of a deep upper limb soft-tissue injury: a) Initial presentation showing a deep soft-tissue defect over the upper limb with exposed muscle belly and disrupted fascial layers following trauma; b) Initial presentation showing a clean defect with delineated tissue margins and exposed muscle structures prepared for repair; c) Appearance at late follow-up (4 months later) demonstrating healed soft-tissue with a large, well-defined scar and tissue contracture along the defect margin; d) Intermediate healing phase showing partial wound closure with scar formation and residual healing along the incision line.

Agricultural upper limb injuries constituted about 11.25% of total upper extremity trauma. In a study by Garg R et al., males were more commonly affected than females. Majority of the patients were in the age group 21-50. Most of the patients were right-handed individuals. Hand injuries were more common (73%) [6].

Singh R et al., (2021) identified threshing machines as the most common causative equipment in North Indian agricultural orthopaedic trauma, paralleling our series, where hay balers and harvesters predominated [7].



[Table/Fig-8]: a) Machine cut injury with distal brachial and proximal ulnar and radial artery injury; b) Post-SVG interpositional graft from distal brachial to ulnar and radial artery done and complete wound healing after 6 months.

Analysis of 53 studies (3 narrative reviews and 50 original articles) indicates that agricultural injuries predominantly affect younger male farmers, particularly during the harvesting season. The upper limbs, especially the hands, are most frequently involved because of their role in operating machinery and tools. Common injury patterns include lacerations, open wounds, fractures, and overexertion-related conditions. Recurrent contributing factors include distraction, inadequate use of protective equipment, and unsafe design of tools or machinery [8].

CONCLUSION(S)

Agricultural machine-cut vascular injuries carry high surgical complexity, yet 100% limb salvage is achievable at specialised tertiary centres even with presentation delays up to 24 hours. Mandatory safety training, regulatory enforcement of equipment standards, and accessible microsurgical referral pathways are priority interventions to reduce the burden of this preventable occupational injury.

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