

Elevator Injuries: Reconstructive Challenge

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Abstract:

Introduction: Escalator and elevator injuries are injuries related to industrialisation and urbanisation of life. The shift of the population from villages to city has led to increase in numbers of high-rise buildings which are more than 10 storied high. High rise buildings more than twenty or thirty storeys are routinely seen in metropolitan cities. All these high rise needs Elevator to go up and down to reach home or office. There are many skyscrapers more than 100 storeyed in this world where fast elevators are used like CN Towers, Burj Khalifa, Tapie 101 etc. The elevators used are very fast, but speed always comes with technical problems and accidents. So human beings have to pay the price of this development.

Material & Methods: This article is a case series of fifteen patients, who had sustained hand injury while using elevator. These injuries are simple CLW, crush injuries, degloved injuries, avulsion injuries of hand or near total to total amputation of fingers tips, fingers including thumb, palm, wrist or elbow. Crush or degloved injury needed debridement and flap coverage, while near total amputation needed revascularisation and flap coverage or skin grafting. While Total amputation needed replantation and coverage.

Results and Observation: These injuries result in bigger zone of trauma and post-operative results vary and depend upon the type of injury crushing or degloved, mechanical force and power of accident, vascularity of distal limb and management of wound.

Conclusion: With the recent technical advancement in wound management and availability of microvascular surgery now it is possible to save the limbs by using various flaps or replantation or revascularisation of amputated limbs. With addition of physiotherapy it's possible to regain near normal lifestyle. But in the end, it's advisable to follow the general guidelines and not to overlook safety protocols to avoid any type of elevator Injury.

Keywords: Elevator Injury, Limb reconstruction, Microvascular surgery.

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Introduction

Elevator or escalator is an electrical and Mechanical machine to transport human beings or weight from one place to another or from one floor to another floor in vertical or horizontal direction both higher or lower floor. It has to work against the gravity so they are very powerful. Injury can happen in various ways, Children playing near the lift [14] .Hand or Fingers getting caught in Iron grill like doors. Or between two doors. Sometime injury can happen when there is mechanical failure of machine or the Pulleys with which the lift is working. Lift is designed so that it would work within given range of distances, but if it is not maintained properly accidents do happened. Sometime base of lift and that of floor are not at same level and passenger may fall while going in or out of the elevators.

Elevators and escalators are potential sources of serious injuries and deaths to the general public and to workers installing, repairing, and maintaining them [12]. Workers are at risk also, for instance, when cleaning elevator shafts, conducting emergency evacuations of stalled elevators, or doing construction near open shafts.

Urbanisation has become one of the indispensable modes of public living. Elevators are ubiquitous in high rise buildings. So public has to use elevators while going or coming out of their houses/offices. Thus, elevators have become an accident prone location. To develop suitable prevention strategies, it is necessary to understand the risk factors that affect the severity of elevator accidents.

The equipment on the elevator may become faulty, the elevator which was going up suddenly reversed and fall, The wire of elevator may get broken down and it falls down resulting into injuries to the passenger[12]. Many times injury is by elevator door. An elevator door consists of an elevator landing door (outer door) and car door (inner door). The injury happens as the limbs get caught between the two doors or door and side frame. There are various type of elevator doors. Manual iron grid doors or Automatic doors like centre opening doors, telescopic doors and Manual doors like collapsible doors, swing doors, imperforate doors, manual telescopic doors, bi-parting doors.

Elevator doors can cause injuries when they malfunction or close too quickly, which can trap passengers or knock them over.

There are different mechanisms of injury [1].

- Crush injury leading to fractures and damage to skin, tendons, neurovascular bundle and soft tissue.
- Pulling forces causing avulsion of neurovascular bundle and soft tissue over it
- Degloving of skin of fingers, hand and forearm due to pulling of hand
- Amputation of stuck limb in the landing door due to upward or downward movement of elevator.

Injuries Can Include:

- Bruises and lacerations
- Fractured bones
- Torn tendons and ligaments
- Severed limbs and amputations
- Organ damage and internal bleeding
- Crush injuries
- Head & Neck or back injuries
- Total paralysis
- Traumatic brain injuries
- Wrongful death

In this case series we are presenting 15 patients who sustained injuries to their limbs due to tapping of limb in the door system of elevators. They underwent reconstructive surgeries as per the injury and type of defects. Simple closure for CLW or local or distant flap coverage with open wounds. Revascularization and Reimplantation of amputated part of limb was done in pt with compromised vascularity.

Materials and Method

In our study, we have taken 15 patients who have sustained injuries to their upper limb by elevator from 2004 to 2024.

In our series we found 60% of survival of replantation surgery. Patients in whom the reimplant was successful had fairly good functional and aesthetic outcome.

All patients with crush injury to the limb presented to our emergency department were examined. If amputated part of limb was brought along with patient, first of all, its appropriate preservation was considered. In case of limb amputation injury amputated parts should be cleaned with saline, wrapped in a moist gauze and placed in a dry plastic bag. The bag should be placed in a container with ice cubes. The container should be labelled clearly with patient's name and identification number.

Brief and important history and consent for surgery was taken and examination of wound done. All routine blood investigations, plain radiographs and if required vascular doppler studies done in all patients. Before taking to surgery patient's relatives were explained about all the pros and cons of micro vascular reconstruction surgery and chances of high failure due to crushing effect of entrapment in elevator door and consent for microvascular surgery is taken.

Patients with crushing, degloved or avulsion injuries debridement of the wound were done and coverage of the wound done with local flap like cross finger flap or distant flap like groin flap or other flaps. Patient with groin flap takes time to understand the gravity of injury, but latter on they cooperate with the treatment.

Cases where amputation has happened the amputated parts were examined under microscope. Then decision was taken whether to replant or not to replant the amputated part.

We follow the systemic protocol for amputation and its management. First debridement of proximal and distal part of amputated segment, neurovascular bundle and tendons were identified and isolated. Then bony stability was achieved by fixation of distal part with the proximal part by K wire or plating. Then vessels were looked back again under microscope and then decision taken for direct repair or repair with vein graft or arterial graft for both artery and vein repair.

Arterial anastomosis were done with 10-0 ethilon. After arterial anastomosis clamps were released and checked for turgidity and vascularity of amputated part. Once satisfactory dorsal part was looked for veins and they were anastomosed with or without vein graft using 8-0 prolene or 9-0 or 10-0 ethilon. Tendons were repaired using 4-0 prolene. Nerves also repaired. Loose dressing applied. Post operatively Injection 2500 IU of heparin given at the time of releasing of clamps. Next day onwards Inj. Clexane 0.4 ml SC given for five days.

In post operative phase limb was looked for vascularity by inspection and blanching of pulp of fingers, temperature of reimplanted limb and by scratch test. If needed doppler ultrasound was also done. For initial five days patients were kept in

critical care unit then patients were shifted to ward and discharged after seven days. Patients were followed for two years.

If the reimplanted limb did not survive then that part was removed and amputation stump was closed with flap or graft coverage.

In our series we found 70% of survival of replantation/ revascularisation surgery. Patients in whom the reimplant was successful had fairly good functional and aesthetic outcome.



Figure 1: Re-implantation of left hand and level of palm.



Figure 2: Re-implantation of left index and thumb



Figure 3: Reconstruction of right hand using free ALT flap



Figure 4: Left thumb re-implantation



Figure 5: Re-implantation of left hand index finger and thumb. Index finger successful. Thumb Unsuccessful.



Figure 6: Reimplantation of Index, Middle, Ring finger. Unsuccessful.



Figure 7: Amputation of right hand index and little finger



Figure 8: Reimplantation of little finger



Figure 9: Re-implantation of little finger left hand



Figure 10: Reimplantation at level of elbow joint

Results and Outcome:

Out of 15 patients there were 10 males and 5 female patients.

Table 1: Average age of patient

Age of patients	Male	Female
<10		2
10-20 years	1	2
20-30 years	3	
30-40 years	4	1
40-50 years	2	

Table 2: Different types of surgeries performed in different patients

Type of surgery	Male	Female
Primary suturing	1	1
Reconstruction by flap	4	1
Replantation	5	3

Table 3: Details of Fifteen patient

S. N.	Age/ Sex	Diagnosis	Surgery	progress	Result	Rehabilitation
1	M/34	Hand Injury lift door	Primary closure	Healed well in two weeks	good	Returned back to own work.
2	F/4	Hand entrapped in lift door with multiple CLW and crushing.	Debridement and primary closure with amputation of non-viable finger.	Wound healed well but took time loss of index and middle finger	satisfactory	Physiotherapy and rehabilitation needed
FLAPS						
3	M/35	Finger injury lift door middle finger with exposed tendons	Debridement and coverage by cross finger flap	Wound healed well	Satisfactory	Physiotherapy And Rehabilitated
4	M/23	Degloved index and middle fingers and non-viable ring fingers	Cross finger flap for middle and index finger with amputation of ring finger	Wound healed with compromise functions	satisfactory	Physiotherapy and Rehabilitation.
5	M/38	Crush Injury ring finger tip due to lift Doors	Debridement and coverage by V-Y plasty flap	Wound healed well.	Satisfactory	Rehabilitated well
6	M/47	Crush injury open wrist	Debridement	Hand	Satisfactory	Rehabilitated

		joint	and groin flap coverage	Survived	ry Result	
7	F/38	Crush injury of hand with exposed tendons	Debridement and Free ALT flap coverage done	Hand survived but with compromised function	Satisfactory result	Compromised result.
		MICROVASCULAR	SURGERY			
8	F/6	Wrist injury with loss of dorsal skin due to Lift door doubtful viability	Debridement Revascularisation and local flap	Wound healed well.	satisfactory	Rehabilitation done
9	F/13	Amputation Through Elbow joint	Replantation at Elbow joint	Wound healed well	Good Result	Pt. Rehabilitated
10	M/32	Amputation through 5 th MCP jt. Little finger	Replantation done	Finger survived	Good result	Rehabilitated
11	M/44	Amputation of four fingers through MCP level	Replantation done but unsuccessful due to Trauma zone effect	Fingers become unsuccessful and become black after 5 th day	Amputation done	Poor result
12	M/17	Amputation through metacarpal level at Mid Palm level	Replantation done .	Wound healed well. And pt regained all his functions in six months	Good	Rehabilitated well
13	M/24	Amputation of thumb and index finger	Replanted done survived	Thumb didn't survived but Index survived.	Satisfactory result	Rehabilitated
14	M/28	Crush injury wrist joint amputation	Debridement and flap coverage	Hand survived but with amputation of ring and middle finger	Satisfactory result	Compromised result.
15	F/11	Crush injury Wrist Amputation	Replantation of wrist	Replantation did not survive and so Amputation was done on 10 th day	Poor result	Compromised

Discussion

Various type of injuries can occur due to elevator like door crush injuries, injuries due to fall and trip of elevator, entrapment inside the cart of elevator lead to suffocation or panic attack, injuries due to unequal levelling of cart with floor etc. [13, 15]

Injury to the upper extremities due to entrapment in the elevator door is a grievous injury. Chances of survival of amputated limb after microvascular

anastomosis is less due to zone of trauma, type of injury and amount of force imparted on the limb

Crush injury happens as compression of upper limb is sustained when the fingers, hand or wrist are caught between two surfaces (sharp, blunt, smooth or irregular) which forcibly produces damage to the skin and its enclosed contents of soft tissues and bone. [1,12] Crush element is always present in case of entrapment injuries even if there is an amputation of limb.

The zone of injury sustained is a function of...

- The applied force
- The velocity of the offending object.
- The width of the offending object.

These three main factors will determine the outcome and extent of the injury. The duration of compression as well as compounding factors such as friction, heat, cold, chemicals and contamination add further damage to the injured area.

In our series limb injury was either simple Contused Lacerated wound or complex crush injury to fingers, palm, wrist or forearm. There were amputation of fingers, mid palm level, wrist joint or at the elbow joint. Simple wound needed primary closure. Crush injury needed debridement and skin grafting or flaps like cross finger flap or groin flap. In case of amputation the amputated part needed Revascularisation or Replantation. We have 3 patients with amputated fingers, 2 with amputation at palm level and 1 with amputation at level of elbow joint.

Elaborating one case was having CLW over index finger, which was sutured primarily. Next patient's hand got trapped which needed debridement and amputation of index and middle finger and coverage by skin graft. In five patients we have to do debridement and some flap. In two patient we did cross finger flap. In one patient VY Plasty. In another one patient Groin flap was needed. While in another we did ALT flap as tendons or bones were exposed. In eight patients we have to do Microvascular surgery. Case of single finger or two finger amputation survived but case of four finger amputation did not survive. Case of badly crushed mid palm level amputation survived. Out of two cases of wrist amputation one with multiple level amputation of fingers only palm and proximal portion was replanted, and that survived. While another case of girl F/10 yrs, replanted wrist remained viable for ten days then it become oedematous and we lost the wrist. In one female 6 yrs old girl there was crush injury to hand we did revascularisation and coverage with flap. We also replanted a case of elbow level amputation in 13yrs old girl. It survived well with good recovery of functions.

In literature very less papers are available for elevator/escalator injuries. But various papers are available for similar upper limb crush and cut injuries and their reconstruction and rehabilitations. Dough Sheeter et al [2] gave severity grading on patterns of injury. In 2010 Hultman et al [3] studied about hot press Hand Injury while Yaffe et al [4] gave study about agricultural machine injuries. In 1983 BJ Gainor et al [5] analysed the mechanism of upper extremity trauma in patients from round hay baler or roller injury. In 2022 T Nutbeam et al [6] published article about entrapment in the motor

vehicle causing injuries in case of road traffic accidents. DH lee et al [7] and ZY Ng et al [8] presented study about escalator related injuries. In 2006 Jennifer et al gave escalator related injuries among children in USA.

Zhi et al [9] gave soft tissue reconstruction of upper extremity. In 2007 Tuna Ozyurekoglu et al [10] analyzed the functional results of upper extremity repair. In their study they found that the ability to replant and the functional outcome of reconstruction is directly related to the degree of initial tissue loss. Alexandra et al [11] gave strategy for reconstruction of mangled upper extremity. They divided the minimum functional requirements of a hand as "basic hand" and "acceptable hand". It is generally accepted that for a hand to be usable, it needs to have an opposable thumb and one or more digits that have adequate motion, sensibility, and length.

Reconstruction of limb depends upon various factors like the type of injury, force of injury, amount of tissue loss, condition of vascularity etc. Availability of facilities and expertise in hospital for reimplantation or revascularisation is also one of the major factors affecting reconstruction. Rehabilitation followed by surgery is one of the important aspect which depends upon sincere physiotherapy. Psychiatric counselling is also required.

This type of injuries can be easily prevented and avoided with a little cautions like [14]...

- Not Forcing open the Doors as this can damage the mechanism and pose a safety hazard.
- Standing clear of closing doors and ensuring oneself fully inside the elevator before it starts moving.
- Keeping eye on children while using elevators
- Observing Weight Limits as overloading can lead to malfunctions.
- Timely checking and servicing of elevators
- Maintenance of electrical system of elevators
- Familiarize yourself with the location of the emergency button and use it in case of any critical situation
- Any unusual noises, movements, or other issues with an elevator should be reported immediately to building management.

Conclusion:

Elevators are recent advancement and are need of today's urban lifestyle. Due to increase in high rise buildings in city, the speed and power of elevators have increased but at the same time it has lead to increase in accidents and injuries. It could be due to Mechanical, electrical, or technical failures. Some time elevators with open doors are also responsible, which are now banned. But injuries do happen with closed automatic doors also. Even different levels of floor and lift base also leads to accidents. Many times these injuries are, crushing, degloving or avulsion type. We have also managed amputation of

fingers, mid palm, wrist or elbow level amputations. The results depends upon the force of injury imparted at the time of accident. It also depends upon other collateral injury over body. Since the area / zone of trauma is bigger, Microvascular surgery like replantation of amputated part of limb is difficult and survival is doubtful. But recent technical advancement in wound managements and Microvascular surgery with better microscopes and trained personal have increased the chances of survival in patients with elevator injuries.

Cases of injury can be decreased if the general public is taught the way of correctly and cautiously using elevators. Prevention of this injury is important for the public and society. As it states, "Prevention is better than cure". Let's vow to use elevators safely.

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