Case study

My hand, my survival: Rehabilitating the Hand for Optimal Function

Abstract

Background: Compartment syndrome is a medical emergency that needs to be treated right away with surgery to stop further complications.

Case presentation: A 54-year-old man presented with acute compartment syndrome of the right upper limb. He underwent fasciotomy, and physiotherapy management started immediately after the surgery. The treatment plan aimed to address pain, preserve muscle function, prevent complications post-fasciotomy, preserve range of motion, strengthen affected muscles, and restore function. The treatment involved a combination of therapeutic interventions and treatment plans and was carried out over a period of 3.5 months. The treatment approach involved passive movements, free active exercises, isometric contraction, assisted active exercises, massage therapy, cryotherapy, electrical muscle stimulation, and scar massage. Throughout the treatment period, the patient's progress was closely monitored, and adjustments were made to the treatment plan as needed. By the end of 12th week, there had been a noticeable improvement in the affected upper limb's UEFI-15 score and gross muscle power.

Conclusions: Pain management, muscle function preservation, and limb function restoration were all achieved successfully with physiotherapy management. The successful outcomes seen in this case study highlight the benefit of early diagnosis and prompt intervention of compartment

syndrome, as well as a team-based, all-inclusive approach to care that includes physiotherapists, medical experts, and other members of the healthcare team.

Keywords: Upper arm compartment syndrome, fasciotomy, physiotherapy, hand

Introduction

The hand is the most fascinating and complex human organ we have after the brain. More than any other anatomical unit, it is employed for natural activities that interact with our artificial world [1]. “The complexity of the hand is evident, its anatomy is efficiently organized to carry out a variety of complex tasks. These tasks require a combination of intricate movements and finely controlled force production. The close relationship between different soft tissue structures contributes to the complex kinesiology of the hand” [1]. “Injury to any of these even very small structures can alter the overall function of the hand and thereby complicate the therapeutic management” [2].

“The complex apparatus of the human hand is used both to grasp objects of all shapes and sizes through the linked action of multiple digits and to perform the skilled, individuated finger movements needed for a large variety of creative and practical endeavors, such as handwriting, painting, sculpting, and playing a musical instrument” [3]. “A key feature of such tool use and manipulation is the ability to control fine movements and forces at individual fingers. This ability to individuate movements of particular fingers from the more fundamental multi digit closure of grasping has evolved to attain the variety of performance found in the human hand”

[4]. “All the joints, together with the tendons, ligaments, nerves, and skin, move smoothly, minimally resisting the gliding movements between the various structures” [5].

“Compartment syndrome is a well-known surgical emergency with high morbidities resulting in potentially long-term debilitation” [6]. “Following trauma, the delicate structures between the tissues might adhere, lose their ability to unfold or stretch, generating restricted lengths and limited free motion in the healing process of the body repairing the tissues. Trauma could result in compartment syndromes similar to Volkmann’s contracture” [5]. “Swelling in the hand and lower arm therefore are a threat of developing such pathology and must be treated immediately. Severe soft tissue damage with tissue disruption, oedemaand hematoma lead to increased interstitial tissue pressure within an enclosed rigid space and consecutive impairment of its content due to ischemia” [7]. “Compartment syndrome is a condition in which increase in interstitial tissue pressure within a closed osteo-fascial compartment leads to microvascular compromise” [8]. “Delay in diagnosis can result in irreversible damage of tissues within the affected compartment, which can lead to limb and life-threatening complications. It is one of the most challenging diagnostic and decision-making problems faced by treating surgeons” [9]. We report a case of post-traumatic unilateral forearm and hand compartment syndrome. To our best knowledge, no such case has been reported in the literature so far.

Case presentation

Patient history

A 54-year-old Nigerian man presented to the adult emergency department 1 hour after he fell from a height on a glass object at his workplace. This resulted in excessive bleeding and dizziness. There was no bleeding from any other site. There was a laceration injury to the medial

compartment of the Right arm, tourniquet was applied, and was rushed to a State General Hospital. The wound was only dressed and referred to the emergency department of our facility. He was conscious but restless, pale, anicteric, and not dehydrated when brought into the emergency department. Bleeding was excessive. The wound was 6cm x 8cm on the lower 1/3 on the Right arm. The patient was unable to move his hand and forearm. There was no fracture. The patient was hemodynamically stable with a Glasgow Coma Scale of 15/15, a blood pressure of 110/70 mmHg, pulse rate of 60 beats per minute, respiratory rate of 24 breaths per minute, body temperature of 36.1 ℃, and oxygen saturation of 98% on room air. Laboratory test results were as follows: hemoglobin 16.3 g/dL; hematocrit 46%;white blood cells 8100/mm3; platelets195,000/mm3; urea 14.5 mg/dL; creatinine 0.8 mg/dL; An overall assessment of complete laceration of the terminal end of the brachial artery of the Right arm was made. The patient was then given 0.5 mL of tetanus toxoid vaccine intramuscularly and administered prophylactic antibiotic using intravenous ceftriaxone. Intravenous Dicolfenac and Intramuscular pentazocin were also given to relieve pain.

The patient was immediately transfused with one pint of blood after the assessment and was subsequently booked for an emergency wound exploration and brachial artery repair a few hours after the presentation. He was operated on and transferred to ward. The affected arm post brachial artery repair and wound exploration were; swelling of the entire Right arm, reduced sensation over the forearm and hand, impalpable radial pulse, no motor function distal to the elbow, hypothermic hand with ischemia. The relatives of the patient were counseled prior to the surgery on the possibility of amputation of the Right forearm if not viable. The patient was still unable to move the hand and forearm and the hand appeared pink than pre and immediate post-operative appearance. The hand was relatively cold compared with the left. The consulting

Physicians made an assessment of Right forearm/arm compartment syndrome following vascular repair and sent a consult to Burns and plastic unit for urgent fasciotomy. Patient had fasciotomy done and radial pulse could be felt thereafter and sensation restored. He was later referred to Physiotherapy for continued management.

Patient is a married in a polygamous setting with two wives and seven children (two females, five males). He is a carpenter by occupation and the bread winner of his family.

Initial examination by Physiotherapists

The patient was met lying supine, stable, and well- oriented. The Right arm was in bandaged dressings. On observation, he was afebrile, acynaozed and anicteric, with no obvious respiratory distress. He had an intravenous cannula on the left forearm and a urinary catheter was *in situ*. He was conscious, alert, and oriented in time, place, and person, but he was looking worried and anxious. The right arm/forearm was bandaged and in a volar slab and met elevated on a pillow. There were blisters at the proximal end of the slab and fingers have prompt capillary refill and swelling at the dorsum of the right hand. Figure 1 shows the right hand post fasciotomy.

The patient was really worried and concerned about the potential impact his condition would have on his chances of getting back to his carpentry work so as to cater for his wives and children. He needed assurances from our team on his chances of using the right hand again and gaining total independence in performing his activities and instrumental activities of daily living.

His vital signs were 120/70 mmHg blood pressure, 98 percent SPO2, 87 beats per minute (bpm) pulse rate, 20 cycles per minute respiratory rate, and 36.6 ℃ temperature.

On physical examination, the patient complained of pain in the Right shoulder, elbow and dorsum of the hand with a rating of 6/10 on the verbal pain rating scale. Physical assessment of the left upper limb and lower limbs showed no abnormality at all. However, the right upper limbs showed some abnormalities. On assessment of the Right upper limb, there was an impaired sensation, loss of proprioception, edematous dorsum of the hand and phalanges. Active range of motion (AROM) was limited in all joints (shoulder, proximal interphalangeal and distal interphalangeal) due to pain while passive range of motion (PROM) was full and painful. The grip strength on the affected arm was poor. The Gross muscle power for the shoulder and elbow was (GMP: 1/5) while the wrist was (GMP: 2/5) as determined by the Oxford grading system (Table 1). The patient's Upper Extremity Functional Index (UEFI-15) score for the Right UL was (2/60) during first assessment (Table 2).

The UEF-15 is a patient-reported outcome measure for quantifying Upper Extremity (UE) function [10] that has been used in several studies of people with musculoskeletal UE problems [11-14]. Scores were assigned to the outcome measures thus; extreme difficulty/unable to do, 0: Quite a bit of difficulty, 1: Moderate difficulty, 2: A little bit of difficulty, 3: No difficulty, 4.

Table 1: Initial Gross muscle power (GMP) according to Oxford muscle grading of the Right UL

		Initial	5th week	12th week
Shoulder				
	Flexion	**1**	**2**	**3**
	Extension	**1**	**1**	**2**
	Abduction	**1**	**2**	**3**
	Adduction	**1**	**2**	**2**
Elbow	**Flexion**	**1**	**2**	**2**

	Extension	**1**	**2**	**2**
Wrist	**Flexion**	**2**	**2**	**3**
	Extension	**2**	**2**	**3**
Radio ulnar joint	**Pronation**	**2**	**2**	**3**
	Supination	**2**	**2**	**3**
Grip strength		**Poor**	**Fair**	**Good**

Table 2: Upper Extremity Functional Index (UEFI-15) scores for the Right Upper Limb

	Initial score	**Score at 6th week**	**Score at 12th week**
1. Any of your usual work, housework, or school activities	0	1	1
2. Lifting a bag of groceries to waist level	0	1	2
3. Placing an object onto, or removing it from, an overhead shelf	1	1	3
4. Washing your hair or scalp	0	1	3
5. Pushing up on your hands (e.g., from bathtub or chair)	1	1	3
6. Preparing food (e.g., peeling, cutting)	0	1	2
7. Driving	0	0	0
8. Vacuuming, sweeping, or raking	0	1	1
9. Doing up buttons (Note: response numbering is correct)	0	1	1
10. Using tools or appliances	0	1	2
11. Opening doors	0	1	2
12. Cleaning	0	1	2
13. Laundering clothes (e.g., washing, ironing, folding)	0	2	2
14. Opening a jar	0	1	2
15. Carrying a small suitcase with your affected limb	0	1	2
TOTAL	**2**	**15**	**28**

Treatment plan and therapeutic intervention

The patient was seen twice a day by the pediatric physiotherapists during the week (Mondays to Fridays), during the morning ward rounds, and during the evening call duty. At the weekends (Saturdays and Sundays), the patient was seen once a day during call duty. The episode of care lasted 3.5 months during which the subject was seen 5 visits/week for a total of 40 visits. Our treatment plan aimed to: 1) relieve pain; 2) preserve the physiological properties of the muscles of the right upper limb; 3) Prevent further complication post fasciotomy; 4) Preserve the ROM in the entire upper limb. 5) Strengthen the affected muscles of the arm/forearm and hand; 6) Restore function.

To accomplish our treatment goals, we began with gentle repetitive passive movements (PM) to the proximal interphalangeal joints (PIP) joints, distal interphalangeal joints (DIP) with a dosage specific prescription of 10reps x 5sets in each joint during the first two weeks of treatment. We decided to start with PM to the PIP and DIP joints because patient has not been able to move the entire limb since presentation due to pain. We started free actives exercises and isometric contraction of the shoulder muscles towards the end of the second week. Assisted active exercises were also performed to the shoulder and elbow joints in gravity eliminated position.

The patient was still having swelling at week 3-5, we ensured that the hand was elevated at all time and incorporated kneading and deep effleurage type of massages to the palmer and dorsum surface of the right hand respectively to aid venous return. The bandage around the affected arm would be removed and sufficient pressure would be applied. We kept on with the isometric contraction of the shoulder muscles, PM to the PIP and DIP at this week as well. At the end of week 5, isometric exercises to the MCP flexors and extensors groups were added to the treatment. We also did stretching to the pectoralis major and minor. Free active exercises were

also performed to the shoulder abductors and adductors. Passive mobilizations to the IP, MCP and wrist joints of the affected hand were also done for the patient. The swelling got reduced also at the end of 5th week. There was significant improvement in the power and UEFI-15 score at the end of the 5th week (Table 1 and 2).

Week 6-10, sustained stretching was done to the flexor compartment of the right hand during the sixth week. The patient was taken to our gymnasium from ward at the seventh session. This was to be able to gain full use of our equipments and receive proper physiotherapy management. Weight bearing exercises to the right upper limb were commenced at our gym, we also made use of cryotherapy to the shoulder, wrist and dorsum of the right hand. We utilized the use of the Electrical Muscle Stimulation (EMS) to stimulate the muscles of the deltoid, elbow flexors, wrist flexors at the sixth week with focus on enhancing muscular activation and functional recovery. We also started scar massage techniques at the beginning of the 9th week using different motions such as; side to side, circular, up and down. Moisturizing oils such as gels and lotions were used to help soften the scar and make scar massage easier and also to avoid skin resistance.

At the 12th week, hand exercises were used as an intervention that aimed to improve the mobility and strength of the hand and therefore, improving functional ability. Exercises to functionally rehabilitate the hand were also incorporated. The GMP and UEFI score were improved significantly at the end of the 12th week (Table 1 and 2).

Figure 1: The affected hand after fasciotomy

Discussion

Compartment syndrome is a medical emergency that requires prompt recognition and surgical intervention to prevent further complications. In this case study, the patient underwent fasciotomy, which is the standard treatment for compartment syndrome. The physiotherapy management started immediately after the surgery to ensure that the patient's limb was preserved and function restored.

As physiotherapists, our primary goal was to work collaboratively with the medical team to support the patient's recovery and improve their overall functional outcomes. We designed a comprehensive treatment plan that aimed to address the patient's pain, preserve the physiological properties of the affected muscles, prevent further complications post fasciotomy, preserve the range of motion in the entire upper limb, strengthen the affected muscles of the arm, forearm and hand, and ultimately restore function. These goals were achieved through a combination of therapeutic interventions and treatment plans.

The treatment approach involved a combination of therapeutic interventions such as passive movements, free actives exercises, isometric contraction, assisted active exercises, massage therapy, cryotherapy, electrical muscle stimulation, and scar massage. The treatment was carried out over a period of 3.5 months, during which the patient was seen five times a week, with a total of 40 visits. Passive movements are often used in the early stages of compartment syndrome to help reduce pain and swelling. A study by Miranda-Klein al [15] found that early passive range of motion exercises were effective in reducing pain and improving function in patients with acute compartment syndrome of the leg. Throughout the treatment period, we closely monitored the patient's progress and made adjustments to the treatment plan as needed. At the end of week five,

we observed significant improvement in the power and UEFI-15 score for the affected upper limb, which indicated that the treatment plan was effective in achieving its objectives.

Conclusions

Overall, the physiotherapy management of this patient with compartment syndrome was successful in achieving the desired outcomes of pain relief, preservation of muscle function, and restoration of limb function. The positive results observed in this case study underscore the importance of early recognition and prompt treatment of compartment syndrome, as well as the value of a collaborative and comprehensive treatment approach involving physiotherapists, medical professionals, and other members of the healthcare team.

Recommendations: While there is on-going advancement in the area of Physical therapy and rehabilitation specific to compartment syndrome and post fasciotomy management, a combination of the listed interventions and prompt early referral for therapy as shown greater outcome. It is thus recommended that early referral; availability of therapeutic modalities such as the Laser therapy, extracorporeal shock wave therapy (EWST) and more work in this area should be promoted to synchronize data for qualitative evidence base practices.

List of abbreviations

GSC: Glasgow Coma Scale; SPO2: Oxygen Saturation Level; PIP: Proximal Interphalangeal Joint; DIP: distal interphalangeal joints; AROM: Active Range of motion; PROM: Passive Range of motion; UL: Upper limbs; LL: Lower limbs; GMP: Gross Motor Power; UEFI-15: Upper Extremity Functional Index; UE: Upper Extremity;

Consent

All written informed consent for medical procedures and patient's medical information study was obtained from the patient to publish this case report. All ethical principles for medical research studies established by our hospital have been followed.

Ethical Approval:
As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

Availability of data and materials

Essential data supporting the findings of this study are available within the article. Further data are available on request from the corresponding author. The data are not publicly available due to privacy reasons.

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