PLASTIC RECONSTRUCTIVE & REGENERATIVE SURGERY

2024;3:87-93
DOI: 10.57604/PRRS-718

INSIDIOUS SPACE OF PARONA INFECTION COMPLICATED BY ACUTE COMPARTMENT SYNDROME OF THE FOREARM IN A DIABETIC YOUNG PATIENT – CASE REPORT

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Summary

Acute compartment syndrome of the forearm is an emergent surgical condition that is uncommonly associated with a suppurative tenosynovitis process, and its prompt identification and management is a must. However, the condition could have some pitfalls, especially when the progression of the infectious process is fast and rapidly extends to the forearm, mimicking a thrombophlebitis or a fasciitis.

We present a case of a 21-year-old diabetic man who suffered from a flexor tendon injury due to a hand cut, complicated with a suppurative tenosynovitis process and a space of Parona collection, presenting to the ER with a full-brown condition of acute compartment syndrome of the forearm.

Key words: space of Parona, acute compartment syndrome, suppurative tenosynovitis, forearm infection

Received: October 27, 2024
Accepted: November 24, 2024
Published online: December 18, 2024

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How to cite this article: Paracuollo M, De Felice D, Lombardi A. Insidious space of Parona infection complicated by acute compartment syndrome of the forearm in a diabetic young patient – Case report. PRRS 2024;3:87-93. https://doi.org/10.57604/PRRS-718

INTRODUCTION

Acute compartment syndrome is an emergent surgical condition of increased pressure in a contained fibro-osseous compartment, leading to impaired perfusion pressure and subsequent neuro-muscular hypoxia or ischemia. The typical scenario for acute compartment syndrome involves upper limb fractures or crush injuries, but also burns, prolonged limb compression, and infections can be associated [1,2].

Irreversible tissue necrosis may occur if ischemia is not treated for more than eight hours, leading to serious limb-threatening complications such as deformity, paralysis, and amputation [3].

The diagnosis of a compartment syndrome highly relies on suspicion and clinical findings, like pain out of proportion, paresthesia, and paralysis of the involved muscles, while pulselessness is actually a late finding [2,4,5]. However, the diagnostic path can have some “shades of gray” in case of an acute compartment syndrome caused by forearm suppurative process, as the pain out-of-control and the functional deficits can be equally shared between infectious cytotoxicity and intra-compartment vascular impairment. Furthermore, the scenario turns into “pitch dark” if the infectious process skips the common evolution of a flexor tenosynovitis, in which

typically the pathogen advances from the wound site through the finger flexor sheet up to the muscle belly.
In this regard, we report a case of a forearm compartment syndrome, due to a primary Parona space suppurative expansion, as a complication of a Verdan Zone 2 hand cut, in which a methicillin-sensitive Staphylococcus aureus (MSSA) skipped digital channel by flowing through the tendon sheath up to the distal forearm [6].

CASE REPORT

A 21-year-old man, with a past medical history including tobacco habit and diabetes mellitus type I, poorly controlled through a subcutaneous insulin infusion pump, presented to the ER with a 5-day history of right hand cut in Verdan zone 2 at his fourth and fifth digits, accidentally inflicted with a knife while cleaning meat in a butchery. After abundant washing of the wound, which appeared completely free of any signs of infective process, he was admitted to the OR and underwent a four-strand flexor digitorum profundus repair for the fourth digit and flexor profundus reinsertion through a pull-out button plus radial collateral nerve suture for the fifth digit. A dorsal arm-cast in standard position was placed to protect the tendon sutures. Tetanus and antibiotic prophylaxis (Cefazolin 2g iv) were administered prior to the surgery, and oral Amoxicillin-Clavulanate 875+125 mg twice a day had been prescribed for the following five days.
He presented back to the outpatients only two weeks after the discharge, with a 48-hour history of progressive pain and swelling, that was initially noted in the hypotenar space and had progressed to involve the distal volar forearm. At presentation, he was febrile at 38°C, with tachycardia and hyperglycemia. Clinical examination revealed that the forearm was extremely edematous, warm and tense to palpation, revealing a decreased global sensation with intense paresthesia in median nerve territory. However, among the four Kanavel's signs of pyogenic flexor tenosynovitis, only a slight flexion position of the digits and severe pain with passive finger extension were clearly appreciable [7,8].
Patchy erythema was evident over the volar forearm and over the dorsum of the hand. The peripheral pulses were faintly palpable, and the distal capillary refill was over 3 seconds, as well as the pain worsening by elevating the limb and attempting passive finger extension. Laboratory findings revealed leukocytosis with neutrophilia (white blood cell count of 14.10 x 109/L, neutrophils 83.5%) and elevated C-reactive protein values of 302.77 mg/L.
An infectious process complicated by an acute compartment syndrome was postulated. The initial differential diagnosis included cellulitis and upper limb deep vein thrombophlebitis. A CT scan with contrast was performed, and upper limb vascular axis were shown pervious, while a fluid collection was appreciated within the middle and distal third of the volar forearm, without signs of gas formation.
Under general anesthesia, emergency fasciotomy and decompression of the volar compartments of the forearm were accomplished through an extensive approach, starting from a Z-shape midpalmar incision, gathered with the previous Brunnel-shape surgical wounds along fourth and fifth finger, across the carpal tunnel with transverse carpal ligament release, and extending longitudinally towards the cubital fossa. Immediate flexor muscles herniation was appreciated after a complete antebrachial fascia release, and almost 25 cc of pus collection poured out of the space of Parona, both extending into the midpalmar space of the hand and infiltrating within the deep flexor musculature of the forearm, causing loss of muscle definition. Conversely, the flexor sheaths of the fourth and fifth finger appeared spared of the suppurative process.
The pus collection was abundantly washed out with 5 L standard 0.9% isotonic saline solution, and soft tissue samples were taken for microbiology.
The median nerve appeared compressed distally by the pus collection and proximally by the oedema in the musculature, so an external neurolysis was performed.
The dorsum of the hand was decompressed by a double dorsal fasciotomy. Wounds were left open, just loosely approximated, for further inspection (Fig. 1). The fasciotomy sites were covered with moist gauze, and a long dorsal arm slab was applied, placing the fingers in an intrinsic plus position.
Post fasciotomy, distal capillary refill returned to less than 3 seconds and pulses were clearly felt at the wrist.
An MSSA was isolated from the intra-operative specimens at the space of Parona, and a broad-spectrum antimicrobial therapy against Gram-positive cocci was started.
Two days after the initial debridement, the detection of a mottling and swelling along the medial surface of the arm led to an ultrasound investigation, which revealed a cellulitis process of the distal third of the medial arm.
A second debridement procedure was promptly performed, by extending the previous surgical incision up to the medial side of the distal arm, with a rich cellulitis serous fluid drainage (Fig. 2).
The patient returned to the OR two more times, for further profuse wound irrigation and soft tissue debridement, and progressively the fasciotomy margins had been approximated by using vascular loops in order to facilitate the following coverage procedure [9].
Clinical conditions gradually improved, up to negative infection markers.

Figure 1. Decompression of the volar forearm compartment through a longitudinal incision, starting from the midpalmar space, across the carpal tunnel and extending proximally along the forearm towards the cubital fossa.

Figure 2. Extension of the previous surgical incision up to the medial side of the distal arm.

Two weeks after the first surgery, he underwent a volar forearm reconstruction surgery by closing directly the fasciotomy site of the hand and the proximal and middle forearm and by covering the distal forearm defect with a suine dermal substitute – Pelnac – (Fig. 3). After three weeks, the silicon external layer of the dermal substitute was removed and a split-thickness skin graft was placed (Fig. 4).

Following the complete adhesion of the skin graft, he experienced a pretty recovery throughout undergoing an extensive rehabilitation program to improve his functional outcomes (Fig. 5). Despite a valid restoration of wrist movements and fair finger extension, as well as of hand sensitivity, a severe grip strength deficit persisted over the follow-up period of four months [10]. Both the flexor digitorum profundus and the flexor pollicis longus had been severely compromised by the intra-compartment ischemia and the infectious myotoxicity.

The patient had been scheduled for a delayed tendon transfer of brachioradialis pro-flexor pollicis longus and extensor carpi radialis brevis pro-flexor digitorum profundus.

DISCUSSION

The space of Parona, which was first described by the Italian anatomist Francesco Parona in 1876, extends from the proximal margin of the carpal tunnel to the mid-forearm [11]. The roof is formed distally by the flexor digitorum profundus tendon and proximally by the belly of the flexor digitorum superficially; the ground is represented by the pronator quadratus distally and the interosseous membrane in the proximal two-thirds. The origin of the flexor digitorum superficialis forms the proximal boundary of this space, which is limited medially by the flexor carpi ulnaris and laterally by the flexor pollicis longus [12].

In 85% of people, Parona's space serves as a communication between the radial and ulnar bursae at the level of the transverse carpal ligament and with the deep midpalmar space of the hand through the carpal tunnel [13]. Typically, Parona's space infections are secondary to suppurative flexor tenosynovitis through direct spreading or throughout the bursae.

No specific clinical test describes clearly an infectious process within the space of Parona. Swelling, tenderness, and occasionally fluctuance of the distal volar forearm are part of the clinical presentation of a Parona space infection, generally combined with loss of normal palmar concavity in cases of mid-palmar space purulent collection [14].

Furthermore, the formation of a suppurative collection within the forearm space increases the compartmental pressure, which in turn facilitates the spreading of the infection by reducing soft tissue perfusion. The noxious process could evolve till a stage of acute compartment syndrome, which occurs when raised pressure within a

Figure 3. **A,B**) Two weeks after the first surgery, the fasciotomy wound was sutured both at the palm and at the proximal and middle forearm, while the remaining distal forearm defect was covered with a suine dermal substitute «Pelnac»; **C**) Wound aspect three weeks later.

Figure 5. Functional outcomes after two months of rehabilitation: valid restoration of wrist movements and fair finger extension, but still an important grip strength deficit, due to the severe compromission of the flexor digitorum profundus and the flexor pollicis longus.

closed osteofascial compartment compromises the circulation and function of soft tissue in that body district [1]. Actually, the forearm is the most common site for compartment syndrome in the upper extremity. Despite the fact that a forearm compartment syndrome is not a rare clinical event, the triggering pathogenic process is uncommonly pyogenic flexor tenosynovitis [15-17].

Figure 4. **A**) Three weeks after Pelnac implant, the silicon external layer was removed and a split-thickness skin graft was placed; **B**) Appearance of the skin graft, two weeks later.

In the specific clinical case, the pathogenetic hypothesis that has been postulated consists of a primary bacteria inoculation through the hand cut and flexor tendons involvement, trauma that happened in a potentially unclean working environment (a butchery), with a subclinical infection process. Despite the right therapeutical approach adopted during the first surgery, consisting of abundant irrigation of the wound and antibiotic prophylaxis, the diabetic comorbidity had progressively helped the bacteria proliferation into the undermined land and indolent dissemination through the synovial sheaths up to the space of Parona, causing micro-thrombosis, tissue necrosis and ending up in abscess formation. The blood flow impairment, depending on the intracompartment pressure increase because of progressive purulent material accumulation, had subsequently promoted the infection spread by causing ischemia and further tissue necrosis towards pathways of decreased resistance. Finally, the microorganisms had also spread through the lymphatics to more proximal soft tissues, causing internal arm cellulitis.

The most frequent cause of septic tenosynovitis, complicated by acute compartment syndrome, is poor initial care and delayed presentation, events that had both happened in the case reported [18]. Jointly, the diabetes

mellitus type I, poorly controlled through a subcutaneous insulin infusion pump, had influenced both the timing and the severity of the clinical presentation [19,21]. Moreover, the smoking habits of the patient could have played an additional role in the septic process and compartment syndrome, through microthrombosis and inflammatory triggering. Actually, both diabetes mellitus and tobacco have been studied as independent risk factors for infectious flexor tenosynovitis, and risk-adjusted prognostic scoring system for surgical wound infectious complications have been published [22-24].

With regard to the pathogen, a MSSA was identified, through culture tests, as to say the most common human pathogen for community soft tissue infection (Fig. 5) [25,26]. Actually, 30 to 80% of hand infections can be attributed to gram-positive cocci, which can also be generally identified in the skin flora, followed by gram-negative bacilli, coagulase-negative staphylococci, *Enterococcus species*, and *Escherichia coli* [27-30].

An extended hand and forearm fasciotomy and accurate debridement are globally considered the standard of care in this scenario. The skin flaps could be left open, waiting for secondary reepithelialization, or could be progressively approximated along with the second-look procedures, up to a complete skin suture. In cases of residual "loss of substance" of the epithelial apparatus, a direct full-thickness skin graft can be considered as well as a dermal substitute, followed by a secondary split-thickness graft [31,32]. In the reported case, it was chosen to cover the distal third of the volar forearm with the suine-derived artificial dermal substitute "Pelnac", a two-layer structure which collagen scaffold, followed by an autologous split-thickness skin graft, after three weeks [33,34].

In the six-month follow-up, the patient presented with no pain, no sensory abnormality, and sufficient hand function for daily activities, despite the inability in grip and pinch strength. The range of passive movement and sensibility were improved significantly, as it was about the same as the unaffected hand at that time [35]. However, according to Tsuge classification, the functional impairment that the patient reported can be described as a moderate type, including contracture of the FDP and FPL with variable findings of the FDS, FCU, and FCR [36].

In order to improve the functional outcomes of the young patient, he had been scheduled for a tendon transfer procedure of brachioradialis pro-flexor pollicis longus and extensor carpi radialis brevis pro-flexor digitorum profundus [37-39].

At the end of this resume, we can state that satisfactory results have been reached after a combination of timely surgical intervention and appropriate medical treatment, as part of a limb-salvage approach.

CONCLUSIONS

It is of utmost importance to suspect an acute compartment syndrome caused by infectious tenosynovitis in similar scenarios, where penetrating injury insidiously progresses from a hand cut and poses a serious threat to the limb. We believe that early diagnosis and aggressive treatment, including administration of antibiotics, early fasciotomy, and debridement of all necrotic tissue, have saved the life and the limb to our patient.

Acknowledgements
The authors thank the nurse staff of the Hand Surgery Department for the assistance given to the data collection.

Conflict of interest statement
The authors declare no conflict of interest.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-forprofit sectors.

Author contributions
MP: A, D, DT, S, W
DP: DT
AL: DT

Abbreviations
A: conceived and designed the analysis
D: collected the data
DT: contributed data or analysis tool
S: performed the analysis
W: wrote the paper

Ethical consideration
The study was conducted ethically, with all study procedures being performed in accordance with the requirements of the World Medical Association's Declaration of Helsinki. Written informed consent was obtained from the patient for study participation and data publication.

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