The Vacuum Phenomenon: A Case Report in the Elbow

Tyler J Smith D.O.[1], Anthony Judice D.O.[1], Salvador Forte D.O.[1], Michael Boniello M.D.[2], Matthew Kleiner M.D.[2] ,David Fuller M.D.[2]

[1]*Philadelphia College of Osteopathic Medicine, Department of Orthopedic Surgery*
[2]*Cooper University Hospital, Department of Orthopedic Surgery*

INTRODUCTION

The presence of intra-articular gas has been well described in the setting of degenerative disc disease, adjacent to vertebral compression fractures, or in traumatic injuries to the axial skeleton.[1,2,3,4] However, the presence of intra-articular gas in the traumatic setting is largely related to open fractures and traumatic arthrotomies.[5,6] The "vacuum phenomenon" (VP) describes the presence of intra-articular gas in closed injuries without open fracture or traumatic arthrotomy.[7,8,9]

PATHOPHYSIOLOGY

The pathophysiology of this phenomenon is due to an abrupt change in joint volume at the time of injury, typically involving distraction, dislocation, or a rebound effect from an external impact.[10,8,11]

In the setting of joint volume expansion, intra-articular pressure is reduced in compliance with Boyle's Law, and the solubility of gas is likewise reduced according to Henry's Law.[8] This allows nitrogen gas to leak from the joint space, resulting in a radiolucent appearance known as the VP.[8,11] In simpler terms, this phenomenon is similar to the underwater creation of air bubbles from the turbulence of a ship's propeller.[11]

DIAGNOSIS

The detection of the VP has been described on various imaging modalities including plain radiographs, ultrasound (US), computer tomography (CT), and magnetic resonance imaging (MRI).[9,12,13,14] In the traumatic setting, the VP is typically diagnosed via CT due to 1) the frequent clinical application of CT in the setting of polytrauma and 2) the high spatial resolution of CT and its ability to detect small quantities of gas.[13,11]

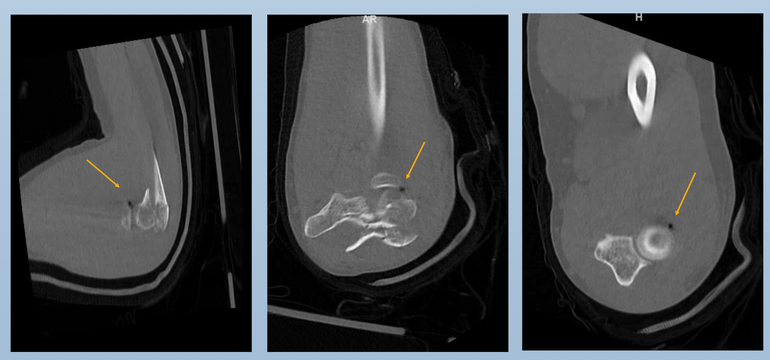
FIIGURE 2: AP RADOGRAPH OF THE LUMBAR SPINE DEMONSTRATNG THE VACUUM PHENOMENON

When intra-articular air in seen in the presence of a fracture or traumatic injury, it is imperative to rule out open fracture or arthrotomy prior to attributing the findings to the VP. We describe a case of the VP in the elbow following a closed, intra-articular distal humerus fracture. To our knowledge this is the first reported case of this phenomenon in fractures about the elbow.

CASE REPORT

FIGURES 3,4: AP & LATERAL RADIOGRAPH DEMONSTRATING A HIGH ENERGY, COMMINUTED, INTRA-ARTICULAR DISTAL HUMERUS FRACTURE

A 33 year-old painter presented as a Level I trauma alert after a fall from a 20 foot scaffolding with an isolated left arm deformity. The skin was inspected for lacerations, open fractures, or elbow arthrotomy. No such injuries were identified, however significant ecchymosis and a large elbow effusion were appreciated. Radiographs demonstrated a highly comminuted, intra-articular distal humerus fracture (Figures 3-4).



FIGURES 5-7: SAGITTAL, CORONAL, AND AXIAL COMPUTER TOMOGRAPHY (CT) SCANS DEMONSTRATNG THE PRESENCE OF AIR WITHIN THE RADIOCAPITELLAR JOINT.

The arm was stabilized temporarily by the trauma service and the patient was taken for CT scan of the head, neck, chest, abdomen, pelvis, and left elbow. No closed head, thoracic, or abdominal injuries were identified. However, CT scan of the left elbow demonstrated intra-articular gas within the radio-capitellar joint (Figures 5-7). Due to concern for a missed open fracture or traumatic arthrotomy, the splint was removed and the skin was re-inspected. Again, no traumatic skin lesions were identified. Traction radiographs were obtained and the arm was stabilized in a well-padded posterior plaster splint (Figure 6). The presence of intra-articular gas was determined to be a result of the vacuum phenomenon.

DISCUSSION

Vacuum pneumarthrography was first described as early as 1910, and the term "vacuum phenomenon" was later coined by Magnusson in 1937.[8] Various pathologies are associated with the VP and include degenerative joint disease, fractures, dislocations, metastasis, osteomyelitis, abscess, joint effusion, joint traction, and Schmorl's nodes.[8] While most commonly observed in the spine and axial skeleton[8,1,2,15,3,4], authors have described the VP in the hip[16,9,12,17], knee[18,19,20], foot and ankle[21,22], hand and wrist[23,24], shoulder[25], and thorax/abdomen[25,26]. However, to our knowledge there are no reported cases of the VP in closed fractures about the distal humerus or elbow.

We hypothesize that the presence of intra-articular air seen on the CT images in our case represent the high energy injury mechanism and the height from which our patient fell. While traction has been reported to result in the presence of the VP[7,8], the traction radiographs performed in the present case occurred following the CT scan and cannot explain the presence of intra-articular gas. The external impact at the time of fracture resulted in a highly comminuted injury pattern (Figures 7-8), joint compression, and was likely followed by rapid articular fragment distraction due to described rebound mechanisms.[8,11] It is possible that ground level falls and lower energy injury mechanisms do not results in significant joint distraction capable of producing the VP. In addition, this phenomenon is grossly underreported[8,15,14], thus the lack of literature regarding this phenomenon in elbow fractures.

CONCLUSION

The presence of intra-articular gas in the setting of fractures and traumatic injuries should prompt physicians to rule out open fractures and traumatic arthrotomies, as these injuries are much more common, alter treatment algorithms, and represent surgical emergencies. The true incidence of the VP is grossly underreported and represents a lack of physician awareness. The VP should remain a diagnosis of exclusion, however physicians should be aware of the pathophysiology of this phenomenon in order to prevent unnecessary patient harm.

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