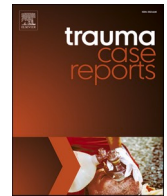




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Case Report

Blistering of the entire lower limb after knee arthroscopy: Benign Subcutaneous Emphysema, Gas Gangrene or Necrotizing Fasciitis? A case report and review of the literature

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Introduction

In arthroscopic surgery the overall complication rates vary from 0.5% to 2% [1–4]. The presence of gas or air in the subcutaneous tissue planes after surgery is rare but differential diagnosis range from benign to potentially life-threatening.

Gas Gangrene (GG) or Necrotizing Fasciitis (NF) are serious systemic conditions caused by gas forming organisms resulting in quickly spreading infection to subcutaneous and deep tissue planes. Gas Gangrene and Necrotizing Fasciitis require immediate and aggressive antibiotic and surgical treatment. In contrast, Benign Subcutaneous Emphysema (BSE) is mostly limited to subcutaneous planes and without systemic symptoms. It is rarely progressive and usually doesn't require any surgical treatment.

The detailed knowledge of symptoms, clinical and radiological appearance as well as a predefined treatment algorithm for BSE, GG or NF is of utmost importance and should be elucidated in this case report.

Case report

A 77-year-old, highly active female patient underwent arthroscopic knee surgery due to a meniscus rupture with persisting pain and locking sensation in her left knee. Ten days after surgery the patient returned with crepitus and palpable subcutaneous emphysema. A gaping lateral portal was revealed once the knee was in a flexed position. The patient complained of slight pain without any apparent clinical signs of infection. Blood analyses revealed a white blood cell count of 8.2 G/l (4–10) and a slightly elevated C-reactive protein of 1.01 mg/dl (0.0–05).

X-rays of the left lower extremity (Fig. 1) showed massive emphysema. In the CT scan a massive subcutaneous, intra- and inter-muscular gas expansion, reaching from the Achilles tendon to the glutei muscles and inguinal region, (Figs. 2–6) was visible.

An early phase of a disease with gas producing bacteria was suspected and an emergency fasciotomy was performed. Soft tissue samples were retrieved and high dose antibiotic therapy was started during surgery. Intra-operative findings showed blistering at multiple locations of the thigh and lower leg but no tissue necrosis or signs of infection (Fig. 7). The muscles appeared to be vital and did contract spontaneously. Intra-operative microscopic analysis of deep tissue samples was negative for clostridia bacteria.

Four days after initial surgery the wounds were closed. Tissue samples, blood cultures and smears didn't reveal any pathological results. C-reactive protein increased to a maximum of 16.5 mg/dl timely related to surgery with a white blood cell count always in a

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Fig. 1. Lateral and anterior- posterior X-rays of the left lower limb, showing emphysema between the muscles as well as gas in the synovial cavity of the knee.

pathological range. Due to postoperative internal medical problems inpatient treatment continued for a total of 27 days with a subsequent outpatient rehabilitation program thereafter. At final examination 128 days after fasciotomy, all wounds had healed and the patient was capable of full weight bearing without any support. The final range of motion of the left knee was 0°–0°–120°.

Discussion

In the presented case a 77-year-old female patient developed massive subcutaneous emphysema three days after suture removal of two arthroscopic portals. After careful clinical and radiological examination, but under the wrong suspicion of an infection with gas producing bacteria, the patient was acutely treated with total fasciotomy of the left lower limb.

The primary learning objective of this case report is the early differential diagnosis of BSE, a rare but not life-threatening medical condition, from serious soft-tissue infections like GG or NF.

Benign Subcutaneous Emphysema following surgery is a rare but recognized complication, which should not be misinterpreted and can be treated conservatively. To the best of our knowledge, this is the first fully documented report of a massive benign subcutaneous and intramuscular gas appearance after suture removal following knee arthroscopy. A literature review revealed only a total of 43 cases of BSE due to low-grade injuries or following minimal invasive surgical procedures other than arthroscopy [5–35]. Other non-infectious causes for subcutaneous emphysema include injuries to the pulmonary tract or intestine e.g. from air guns or high-pressure devices, blast injuries, cutaneous ulcers, dental extractions, chemical reactions [36] or even self-induced emphysema [37,38].

Due to the mechanical genesis of the BSE, gas instillation usually starts immediately after the barrier of the skin is broken but can also be delayed for several days [39]. Especially in post-operative patients or patients who are immobilized after surgery, the development of BSE may take longer.



Fig. 2. Sagittal CT slice of the lower limbs showing massive subcutaneous, intra- and intermuscular gas instillation in the left lower limb. L1 to L4 marks the level of the coronary CT slices shown in [Figs. 3–6](#).

In the present case, the authors hypothesize that following early suture removal, the gaping arthroscopic portal acted like a one-way flap valve. When the knee joint was bent, air got trapped in the subcutaneous tissue which was then pressed in the subcutaneous and interfascial planes during extension.

If a patient presents with clinical or radiological findings similar to BSE, GG or NF (see [Table 1](#)), it is of utmost importance to have a clear and structured working path in order to avoid misinterpretations, since initial symptoms may be similar in all three conditions. As has been seen in this special case, but in contrast to typical radiological findings of BSE, gas must not be limited to subcutaneous levels. Probably due to fascial injury or perforation paired with high pressures produced by the continuous air entrapment by the valve mechanism, the gas can reach deeper tissue planes or even become intramuscular and therefore mimic radiological findings of GG or NF.

In the present case the massive subcutaneous, interfascial and intramuscular air was misinterpreted as the initial phase of a serious and life-threatening condition and the patients was treated accordingly.

In order to avoid similar cases in the future the authors recommend the following approach if a subcutaneous emphysema is

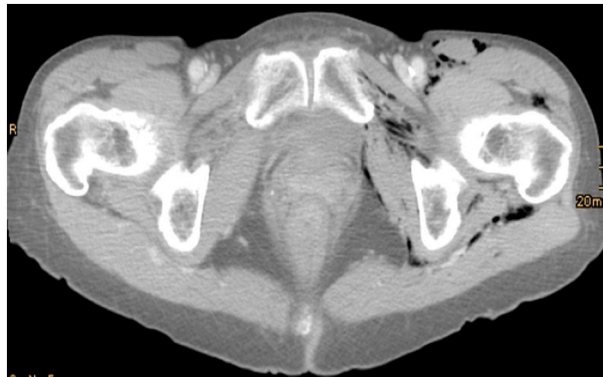


Fig. 3. Coronary CT slice at the level L1 showing gas in the gluteal muscles and lower pelvis.

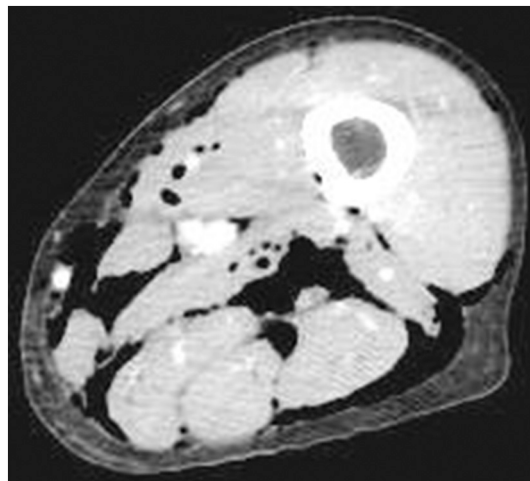


Fig. 4. Coronary CT slice at the level L2 of the left thigh showing subcutaneous, intra- and intermuscular gas.

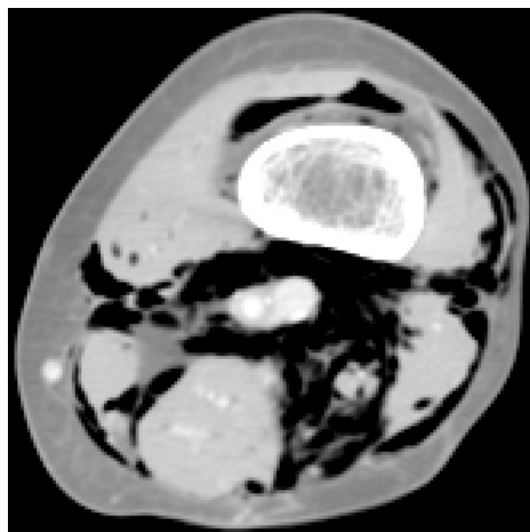


Fig. 5. Coronary CT slice at the level L3 of the left thigh showing gas instillation also intra articular.

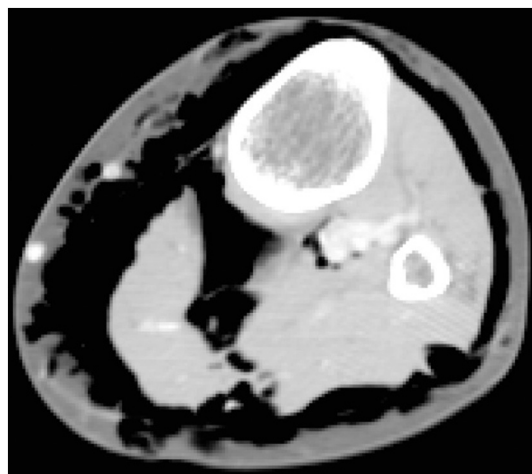


Fig. 6. Coronary CT slice at the level L4 showing subcutaneous, inter- and intramuscular gas at the left lower thigh.

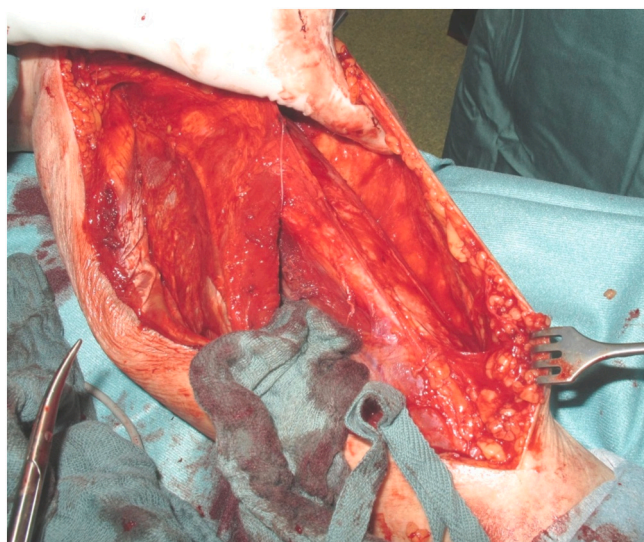


Fig. 7. Intraoperative situs. No fascia or muscular necrosis were found.

diagnosed: first, an extensive anamnesis including the genesis of the wound and the timely relation to the development of the subcutaneous emphysema is essential. It is important to remember, that in immobilized patients the development of the emphysema might be delayed. In subjects with massive and/or worsening pain GG or NF must be suspected. Second, wound inspection should be performed and tissue samples should be taken for immediate gram staining and culture. An initial erythema with hardening of the skin and swelling beyond the area of skin change are the initial sign of a more serious condition. In the presence of a livid skin colour or even haemorrhagic blisters GG or NF is likely. Third, blood analysis including white blood cell count, sodium level and ureic acid should be obtained. Last, injuries of the airway system or the intestines need to be ruled out.

An infection with gas producing bacteria is unlikely a) if the wounds are unsuspecting and without any inflammatory skin changes, livid skin areas or haemorrhagic blisters, b) in the absence of severe pain or extreme tenderness, c) if no signs of toxicity or shock are present, d) if laboratory markers remain within the physiological range e) with preserved vigilance and f) if the emphysema is radiologically confined to subcutaneous regions and fascial planes without any signs of infection. In any other cases and if there is any doubt about the diagnosis, a surgical revision is indicated.

If a life-threatening disease was ruled out, patients should be observed for 24 h and treated with intravenous broad-spectrum antibiotics covering anaerobic and aerobic bacteria. Vital signs have to be monitored and serial examinations performed. Immobilization and elevation of the affected extremity is recommended to disrupt the valve mechanism and allow for absorption of the emphysema. If symptoms progress, especially with increasing pain, rise of laboratory markers or if the patient gets systemically unstable Gas Gangrene or Necrotizing Fasciitis has to be suspected and an immediate surgical exploration is recommended [39].

Table 1
Common findings in Benign Subcutaneous Emphysema (BSE), Gas Gangrene (GG) and Necrotizing Fasciitis Type II (NF II).

	BSE	GG	NF II
Causative agent	Air, non-infective	Clostridia bacteria	Group A streptococcus, mixed infection
Time to gas appearance	6–10 h or longer	Up to 18 h	Up to 18 h
Skin	Normal	Normal to initially pale	Normal to initially erythema
Common clinical symptoms	Crepitus, swelling and tightness, mild pain and tenderness	Massive pain, fever, crepitus, systemic toxicity, blisters containing foul smelling brownish liquid with gas bubbles, indurations and oedematous and tense wounds, shock	Pain out of proportion, swelling, fever, erythema, bullae formation, skin indurations, skin necrosis, sensory and motor deficits, painless ulcers, hypotension and acidosis, shock
Blood analyses			
White blood cells	Normal	Elevated	>14,000 cells/ μ l
Sodium	Normal	–	<135 mmol/l
Ureic acid	Normal	–	>15 mg/dl
Myoglobin urine	Normal	Elevated, no red blood cells	–
Tissue damage	None	Muscle, soft tissue	Fascia and soft tissue, skin
Wounds	Unsuspectious	Initially may be pale	“Murky dishwater fluid”
Radiographs	Gas along tissue planes	Gas instillation between the muscle fibres	Gas along tissue planes not in all cases
Ct-scan	Gas usually limited to subcutaneous and interfascial planes	Gas instillation between the muscle fibres, signs of infection	Asymmetric thickening of fascia, non-enhancing tissues, fluid collection, gas across tissue planes not in all cases
Intraoperative findings	Blistering, gas, no signs of infection	Muscles from darkish red to black, non-contractile and not bleeding when cut	Fascia from dull red to grayish white, necrosis, muscle usually spared

Conclusion

Benign Subcutaneous Emphysema (BSE) is a rare complication after minimal invasive surgical interventions including knee arthroscopy, which can commonly be treated conservatively. However, a detailed anamnesis, wound inspection, radiological examination using X-ray and CT scans as well laboratory markers and blood analysis are required to rule out any serious and life-threatening diseases like Gas Gangrene or Necrotizing Fasciitis.

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Informed consent

Informed consent was obtained from the patient.

CRedit authorship contribution statement

AR: Writing and drafting of the manuscript, Critical review
 FS: Writing and drafting of the manuscript, Critical Review
 RM: Data acquisition, Critical Review
 DM: Writing and drafting of the manuscript, Critical Review
 TR: Concept and design, Critical Review
 CR: Concept and design, Data acquisition

Declaration of competing interest

The author(s) declare that they have no competing interests.

References

- [1] Committee on Complications of Arthroscopy Association of North America, Complications of arthroscopy and arthroscopic surgery: results of a national survey, *Arthroscopy* 1 (1985) 214–220.
- [2] Committee on Complications of the Arthroscopy Association of North America, Complications in arthroscopy: the knee and other joints, *Arthroscopy* 2 (1986) 253–258.
- [3] O.H. Sherman, J.M. Fox, S.J. Snyder, W. Del Pizzo, M.J. Friedman, R.D. Ferkel, et al., Arthroscopy–“no-problem surgery”. An analysis of complications in two thousand six hundred and forty cases, *J. Bone Joint Surg. Am.* 68 (1986) 256–265.
- [4] N.C. Small, Complications in arthroscopic surgery performed by experienced arthroscopists, *Arthroscopy* 4 (1988) 215–221.
- [5] Y. Amsalem, E. Lin, M. Salai, M. Pritsch, H. Horoslawski, Extensive subcutaneous emphysema complicating arthroscopy of knee, *Br. J. Sports Med.* 19 (1985) 167.

- [6] W.H. Brummelkamp, Tissue emphysema of the hand and fore-arm simulating gas gangrene infection, following minimal injury. Report on six cases, *Arch. Chir. Neerl.* 16 (1964) 227–235.
- [7] M. Butt, G.F. Hird, Surgical emphysema of the dorsum of the hand, *J Hand Surg Br.* 15 (1990) 379–380.
- [8] J.A. Clavijo-Alvarez, G. Stofman, Noninfectious subcutaneous emphysema of the upper extremity, *Plast. Reconstr. Surg.* 123 (2009) 154e–155e.
- [9] T. Constantine, U. Musharrafieh, A. Rammal, S. Moukaiber, R. Haider, Non-infectious subcutaneous emphysema of the hand: a case report and review of the literature, *Emerg. Med. J.* 27 (2010) 383–386.
- [10] J.A. Crampton, An unusual case of surgical emphysema, *Injury Extra.* 36 (2005) 225–227.
- [11] M. De, J. Stevenson, Subcutaneous emphysema of upper limb, *Emerg. Med. J.* 18 (2001) 522.
- [12] N.V. Deshmukh, M.M. Shah, Extensive subcutaneous emphysema following arthroscopy: a case report, *Knee Surg. Sports Traumatol. Arthrosc.* 10 (2002) 119–121.
- [13] J. Dexel, W. Schneiders, P. Kasten, Subcutaneous emphysema of the upper extremity after elbow arthroscopy, *Arthroscopy* 27 (2011) 1014–1017.
- [14] P. Driscoll, R.S. Gunn, D.L. Douglas, Subcutaneous suction emphysema of the elbow, *Injury* 16 (1984) 134–135.
- [15] J. Fernyhough, B.E. Razza, Tension pneumarthrosis complicating arthroscopy of the knee, *Am. J. Sports Med.* 20 (1992) 479–480.
- [16] R.M. Filler, N.T. Griscom, A. Pappas, Post-traumatic crepitation falsely suggesting gas gangrene, *N. Engl. J. Med.* 278 (1968) 758–761.
- [17] A. Fox, H. Sheick, C. Ekwobi, M. Ho-Asjoe, Benign surgical emphysema of the hand and upper limb: gas is not always gangrene—a report of two cases, *Emerg. Med. J.* 24 (2007) 798–799.
- [18] S. Hamilton, M.J. Towers, J.M. Pegum, Pneumomediastinum due to a sucking wound of the knee, *AJR Am. J. Roentgenol.* 152 (1989) 1131–1132.
- [19] C.E. Henderson, C.N. Hopson, Pneumoscrotum as a complication of arthroscopy. a case report, *J. Bone Joint Surg. Am.* 64 (1982) 1238–1240.
- [20] P.S. Jorgensen, C. Torholm, Post-traumatic subcutaneous emphysema—misdiagnosed as gas gangrene, *Ugeskr. Laeger* 152 (1990) 2512–2513.
- [21] T. Khalil, R.J. Newman, Gas in the soft tissues following a penetrating wound—gangrene or not gangrene? *Injury* 25 (1994) 337–338.
- [22] R.K. Knight, Subcutaneous emphysema of the leg, *Br J Clin Pract.* 37 (1983) 192–193.
- [23] B. Lehmann, M. Haberkern, B. Liechi, C. Zellweger, Crepitus under the skin - harmless or life-threatening? *Schweizer Med Forum.* 6 (2006) 101–102.
- [24] S.J. Lo, J. Hughes, A. Armstrong, Non-infective subcutaneous emphysema of the hand secondary to a minor webspace injury, *J. Hand Surg. Br.* 30 (2005) 482–483.
- [25] A.J. Logan, S. Roy, C. Wilson, Emphysema of the knee and thigh following excessive use of the Mitek vaporizer during arthroscopy of the knee, *Clin. J. Sport Med.* 12 (2002) 182–183.
- [26] M. Ozalay, S. Akpınar, M.A. Hersekli, G. Ozkoc, R.N. Tandogan, Benign noninfectious subcutaneous emphysema of the hand, *Arch. Orthop. Trauma Surg.* 123 (2003) 433–435.
- [27] M. Saleh, S.R. Bollen, Sucking wound of the knee: not gas gangrene, *Br. Med. J. (Clin. Res. Ed.)* 289 (1984) 1348.
- [28] J. Stevenson, Sucking wounds of the limbs, *Injury* 26 (1995) 151–153.
- [29] W.H. Tiong, F.S. Butt, Subcutaneous emphysema of the upper extremity following penetrating blackthorn injury to the wrist, *J. Plast. Reconstr. Aesthet. Surg.* 62 (2009) e29–e32.
- [30] J.L. Udell, M.E. Julsrud, Subcutaneous emphysema of the lower extremity. A case report, *J. Am. Podiatr. Med. Assoc.* 80 (1990) 446–447.
- [31] A.B. van der Molen, M. Birmendorf, W.W. Dzwierzynski, J.R. Sanger, Subcutaneous tissue emphysema of the hand secondary to noninfectious etiology: a report of two cases, *J. Hand Surg. Am.* 24 (1999) 638–641.
- [32] M.F. Wallace, I.G. Mackie, I.C. Dickinson, A nonbacterial cause of post-traumatic soft-tissue gas, *J. Trauma* 28 (1988) 254–255.
- [33] G. Walter, F. Welsch, R. Hoffmann, Intercompartment soft tissue emphysema after arthroscopic meniscus resection: case report and differential diagnosis, *Unfallchirurg* 115 (3) (2012) 226–233.
- [34] A.B. Williams, N.O. Aston, Sucking injury or gas gangrene? *Ann. R. Coll. Surg. Engl.* 81 (1999) 115–116.
- [35] J.S. Winshall, B.N. Weissman, Images in clinical medicine. benign subcutaneous emphysema of the upper extremity, *N. Engl. J. Med.* 352 (13) (2005) 1357.
- [36] D.L. Stevens, A.E. Bryant, The role of clostridial toxins in the pathogenesis of gas gangrene, *Clin. Infect. Dis.* 35 (2002) S93–S100.
- [37] J. Aggelidakis, K. Lasithiotakis, A. Topalidou, J. Koutroumpas, G. Kouvidis, P. Katonis, Limb salvage after gas gangrene: a case report and review of the literature, *World J Emerg Surg.* 6 (2011) 28.
- [38] C.M. Larson, M.P. Bubrick, D.M. Jacobs, M.A. West, Malignancy, mortality, and medicosurgical management of clostridium septicum infection, *Surgery* 118 (1995) 592–597, discussion 597–598.
- [39] O. Assadian, A. Assadian, C. Senekowitsch, A. Makrithathis, G. Hagmuller, Gas gangrene due to *Clostridium perfringens* in two injecting drug users in Vienna, Austria. *Wien Klin Wochenschr.* 116 (2004) 264–267.