

# We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

186,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index  
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?  
Contact [book.department@intechopen.com](mailto:book.department@intechopen.com)

Numbers displayed above are based on latest data collected.  
For more information visit [www.intechopen.com](http://www.intechopen.com)



## Emphysematous Pancreatitis

Audrius Šileikis  
Vilnius University,  
Lithuania

### 1. Introduction

#### Emphysematous (gas-forming) infections of the abdomen and pelvis

Emphysematous (gas-forming) infections of the abdomen and pelvis represent potentially life-threatening conditions that require aggressive medical and often surgical management. The initial clinical manifestation of these entities may be insidious, but rapid progression to sepsis will occur in the absence of early therapeutic intervention. Conventional radiography and ultrasonography are often the initial imaging modalities used to evaluate patients with abdominopelvic complaints. However, when a differential diagnosis remains, or if further localization or confirmation of tentative findings is needed, computed tomography (CT) should be considered the imaging modality of choice. CT is both highly sensitive and specific in the detection of abnormal gas and well suited to reliable depiction of the anatomic location and extent of the gas. Of equal importance may be the capability of CT to help reliably identify benign sources of gas, because treatment (if any) varies dramatically depending on the source. Knowledge of the pathophysiologic characteristics, common predisposing conditions, and typical imaging features associated with gas-forming infections of the gall-bladder, stomach, pancreas, and genitourinary system will help make early diagnosis and successful treatment possible. In addition, such knowledge will aid in further diagnostic work-up, surveillance of potential complications, and evaluation of therapeutic response. The presence of gas within the parenchyma of solid organs or the walls of hollow viscera may be due to a variety of pathologic or benign entities. Besides infection with gas-forming bacteria, other possible sources include bland tissue infarction with necrosis, enteric fistula formation, and reflux from an adjacent hollow viscus. Gas should be differentiated from atmospheric air introduced at recent instrumentation or surgery. Gas associated with infection is generally thought to consist of carbon dioxide and nitrogen secondary to the fermentation of glucose by some species of bacteria. Poor glycolysis at the tissue level in diabetic patients results in increased glucose concentrations within the interstitial fluid. Other clinical factors that contribute to the increased production or slowed removal of gas include a depressed cell-mediated immune response, local tissue necrosis, and the presence of arteriosclerosis. The increased pH of bile associated with gallbladder inflammation and the focal tissue ischemia seen in gynecologic neoplasms are examples of specific underlying processes that help optimize bacterial culture media. In addition to broad-spectrum antimicrobial therapy and possible surgery, correction of associated underlying conditions such as urinary outflow obstruction, acid-base and electrolyte

imbalances, hypovolemia, and hyperglycemia is imperative. In the setting of gas-forming infections, clinical outcome will, in large part, depend on whether early diagnosis and treatment are achieved. The presence of comorbid conditions and equivocal physical examination findings may prevent rapid diagnosis or delay appropriate initial therapy. Consequently, appropriate radiologic imaging with prompt, accurate interpretation plays an important role in the diagnosis and management of these diseases.

## **2. Main heading, emphysematous pancreatitis**

The most common causes of acute pancreatitis are the passage of gallstones and alcohol abuse. An overall mortality rate of 4% rapidly escalates to more than 50% when complications (eg, abscess formation, superinfection with gas-forming bacteria) occur. The infecting organisms are usually coliform bacteria and may reach the pancreatic bed by way of the bloodstream or lymphatic channels, a fistula from adjacent bowel, transmural passage from the transverse colon, or reflux of enteric organisms into the pancreatic duct or biliary tree via a patulous ampulla of Vater. Gas may be detected in up to 22% of pancreatic abscesses; however, its presence alone is not specific for the diagnosis of infection. Other sources of intraductal or parenchymal pancreatic gas include reflux from the duodenum following sphincterotomy, endoscopic instrumentation, enteric fistula (commonly involving the transverse colon), and end-organ infarction. Patients with emphysematous pancreatitis are usually debilitated and often have underlying immunocompromised conditions such as poorly controlled diabetes or chronic renal failure, atherosclerosis, tuberculosis, HIV infected individuals.

### **2.1 Secondary heading**

Retrospective review of literature, and our one experience of treatment 8 patients with emphysematous pancreatitis in our department from 2003 to 2011.

#### **2.1.1 Tertiary heading, left justified**

Early radiographic detection of retroperitoneal gas is critical in the evaluation of superimposed emphysematous infection of the pancreas. Conventional abdominal radiography may demonstrate mottled gas overlying the midabdomen (Fig 1).

This finding is not specific for pancreatitis because abscesses involving the lesser sac or perinephric space may also have this appearance. Diagnostic US is often of limited value in the evaluation of acute pancreatitis or its complications secondary to an adjacent air-filled small bowel loop from ileus. When identified, pancreatic gas will manifest as multiple irregular echogenic foci, often with posterior dirty acoustic shadowing. A significant volume of gas may limit the detection of adjacent fluid collections. CT is the modality of choice for detecting parenchymal gas as well as evaluating its extent and location (Fig 2, 3).

Fluid collections or portal venous air are readily identified, and, although intravenously administered contrast material is not necessary for the visualization of air, it is useful for evaluating potential complications including parenchymal necrosis and abscess formation. The prognosis for emphysematous pancreatitis is grave, and successful treatment requires



Fig. 1. Emphysematous pancreatitis in a 66-year-old woman. Digital scout image from a CT scan demonstrates a mottled collection of gas bubbles in the midportion of the upper abdomen and extending into the left upper quadrant.

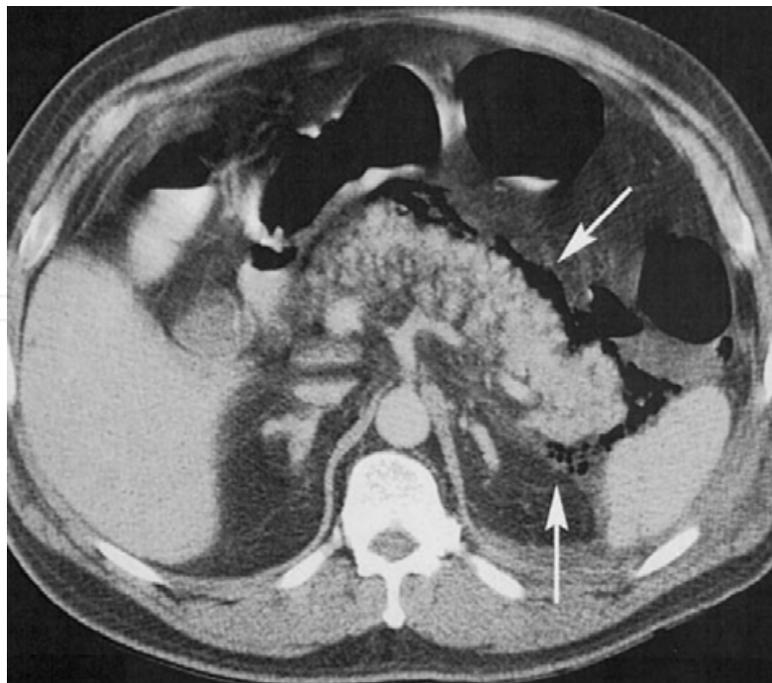


Fig. 2. Emphysematous pancreatitis in a 66-year-old woman. Contrast-enhanced CT scans obtained at the same level as a show gas surrounding the body and tail of the pancreas (white arrows) and extending more cephalic within the anterior pararenal space.

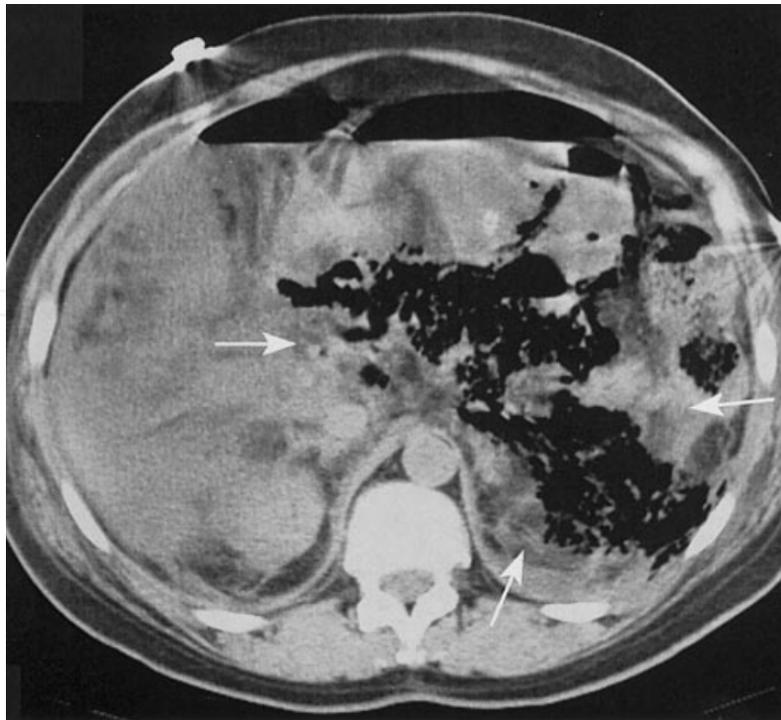


Fig. 3. Contrast-enhanced CT scans in a 66-year-old woman with emphysematous pancreatitis. There are extensive inflammatory changes involving the surrounding fat (white arrows).

aggressive management of the infection with systemic antimicrobial therapy and control of septic shock. Usually emphysematous pancreatitis occurs at the onset of the disease – first week of the illness, but some times it can manifest later on. There is at present a tendency to operate patients with infected necrosis as soon as the diagnosis is made, regardless of the clinical status. It is well known that pancreatic abscesses represent a distinct clinical entity and that they are treatable by nonoperative management, including percutaneous drainage. Similarly, selected patients with localized infected necrosis amenable to endoscopic, transgastric drainage can be managed with this interventional technique. There are some patients with retroperitoneal gas in the setting of severe acute pancreatitis who were treated with focused long-term (3-7 weeks) antibiotics; allegedly the infected necrosis resolved without any interventional drainage or necrosectomy. The emergence of a few cases treatable medically, though small in number, may be due in part to better intensive care and in part to improved antibiotic therapy. However, the lesson learnt from these cases is that some patients may improve without intervention. The above observations suggest the need to correlate clinical versus imaging and bacteriologic findings in acute pancreatitis with infected pancreatic necrosis. Not all patients with infected pancreatic necrosis may need intervention. 368 patients with severe acute necrotic pancreatitis were treated in our department from year 2003 to 2011, including 8 (2%) patients who had developed emphysematous pancreatitis. The data of these patients are presented in Table 1.

The patient's age averaged was  $73,9 \pm 4,8$  years. All of them had manifestation of atherosclerosis (ischemic stroke, myocardial infarction, ischemic heart disease) four had metabolic syndromes such as hyperglycemia, one gastric and another one prostate cancer.

Parameter	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
Age, years	72	66	74	67	79	80	80	73
Sex	female	male	male	female	male	male	male	female
Appache II	18	23	16	8	17	22	10	18
CT evidence of necrosis degree	30-50%	30-50%	<30%	<30%	<30%	>50%	<30%	30-50%
Necrosis localization	head	head	head	tail	head	tail	head	head
Glucose during admission mmol/l	12,5	10,2	7,0	11,3	6,9	11,7	6,0	5,8
Comorbid illnesses	IS	IS	MI	ISH	ISH; CaV	MI; CaP	ISH	IS; ISH
Time of gas CT detection*	7	3	3	4	2	2	11	6
Time of the operation**	15	4	3	-	3	3	13	7
Type of the operation	closed	open	open	-	open+G	open	open	open
Number of debridment	2	1	1		3	0	1	1
Hospital stay, days	114	60	78	22	14	3	41	43
Outcome	recovery	recovery	recovery	recovery	dead	dead	recovery	recovery
Cultures of necrotic pancreas tissue	E. coli	E. coli; Pr	E. coli	-	E. coli; Bf	Ef	E. coli	E. coli

Table 1. Patients data treated in our department. IS - ischemic stroke; MI - myocardial infarction; ISH - ischemic heart disease; CaV - gastric cancer; CaP - prostate cancer; \*Time of intrapancreatic gas CT detection, days from the onset of the disease; \*\*Time of the operation, days from the onset of the disease; closed - closed lavage; open - open packing; G - gastrectomy; Pr - *Providentia rettgeri*; Bf-*Bacteroides fragilis*; Ef - *Enterococcus faecalis*;

The trigger of the development of emphysematous pancreatitis in all cases was passage of gallstones. All of these patients had calculous cholecystitis and choledocholithiasis. Most of them CT scan showed pancreatic necrosis, retroperitoneal and intrapancreatic gas trapping in the first week of the disease. Necrosis with intrapancreatic gas trapping occurred more frequently in pancreatic head (six cases), less in pancreatic tail (two cases). Six patients, for whom vasopressor-noradrenaline doses were increased to 0,4 µg/kg/min to provide sustainable hemodynamics due to bacteremic shock, had been successfully treated by extensive pancreatic necrosectomy, open packing with debridement immediately after CT diagnosis of emphysematous pancreatitis. One female patient was treated with antibiotics (ciprofloxacin and metronidazole), oxygen therapy, fluid and electrolyte correction and

nasojejunal feeding for 9 days, followed by necrosectomy and continued lavage due to failure of organs. One patient at the same time had emphysematous pancreatitis and cholecystitis. All operated on patients had infected pancreatic necrosis which was confirmed bacteriologically. *Escherichia coli* infection was present in six patients, additionally *Bacteroides fragilis*, *Providentia retgeri* and *Enterococcus faecalis* were cultured respectively. Emphysematous pancreatitis requires urgent surgical management at the onset of disease due to multisystem organ failure and patient instability. Ordinarily early surgical interventions mortality rates are reported as at least 50%, and morbidity can approach 100%. Ideally, surgery should be delayed at the earliest of 3rd or 4'th week of illness until the necrosis has demarcated and organized. At that time, the necrosectomy is technically easier, and there is generally improved mortality and morbidity. However, we found that in cases of emphysematous pancreatitis, pancreatic necrosis is already demarcated and organized at the first week, which is enough to repeat one or two additional necrosectomies for the patient full recovery. The hospital stay was significantly shorter too. In comparison for the other our patients with open packing: an average of time of the operation from the onset of the disease was 29 days, overall hospital stay - 93 days and 4,2 additional necrosectomies for the patient full recovery. We also found that minimally invasive procedures in patients with emphysematous pancreatitis are not available, since fluid collections are absent. One patient (case 4) with overt inflammatory indices - C-reactive protein 177,7 mg/l, white blood cells  $16 \times 10^9$ , febrile temperature  $38,7\text{ }^{\circ}\text{C}$  - on first presenting presenting, underwent conservative treatment regimen after radiological detection of emphysematous pancreatitis (fig.4.).

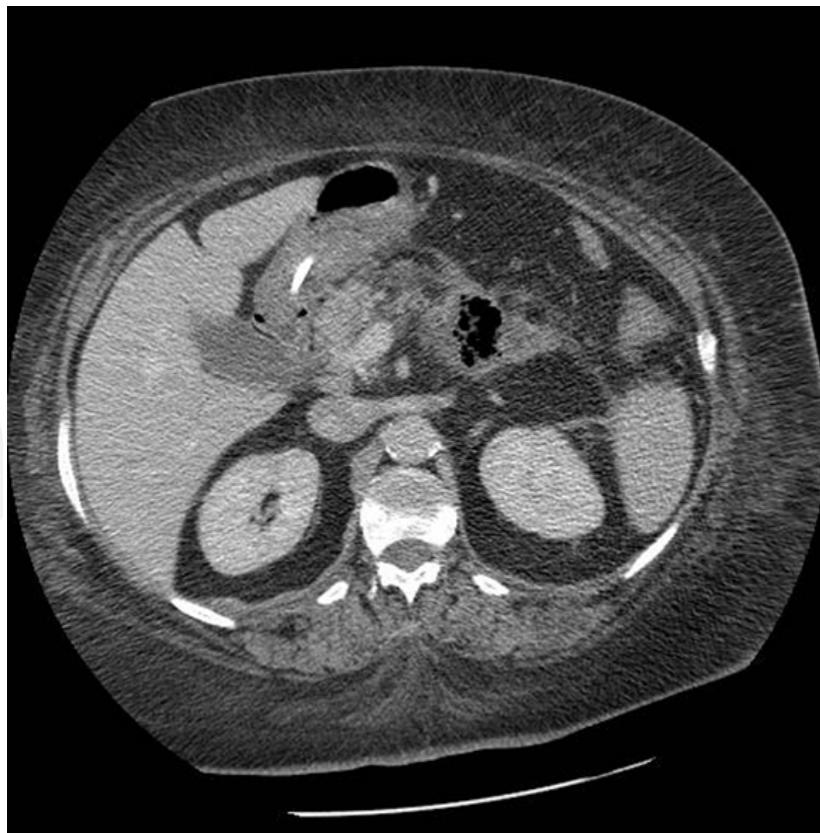


Fig. 4. CT scan showing less than 30% pancreas tail necrosis with intrapancreatic and retroperitoneal gas.

This patient did not undergo a puncture for the bacteriological proof of infection based on the supposition of the possibility to confirm the radiological suspicion of infected pancreatic necrosis during the operation. Since no surgical interventions were performed on the non-operated patient previously, there was no enteric fistula, and pancreatic necrosis was localized in the middle of parenchyma, we therefore considered clinical and CT data to be sufficient in this case for the proof of infection of pancreatic necrosis. Following successful conservative treatment, however, the patient avoided the operation, and, therefore, the causative agent of the infected pancreatic necrosis was not verified. CT follow-up for this female patient was performed in 8 weeks and in 3 months respectively showing complete intrapancreatic and retroperitoneal gas disappearing (fig. 5).

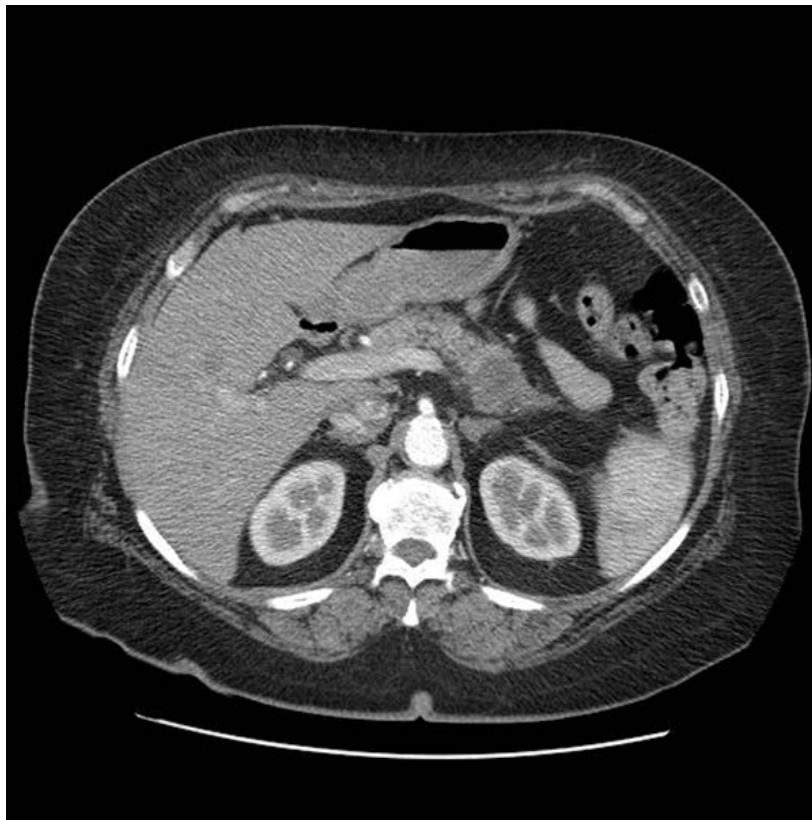


Fig. 5. CT scan showing resolution of intrapancreatic and retroperitoneal gas after 8 weeks

We suggest that the main factor determining such different outcomes of emphysematous pancreatitis in patients of similar age and with similar comorbidities and extend of the necrosis is the varying localization of necrosis in the pancreas. Necrosis in the pancreas head showing higher vascularization than the pancreatic tail is associated with a lower frequency of massive intoxication and organ failure necessitating surgical intervention. Other authors reported some cases of successful antibiotic treatment of infected pancreatic necrosis located in the pancreatic tail as well. In these cases, however, infected pancreatic necrosis was identified later on, not at the onset of the disease, and the number of the cases is too small to draw valid conclusions.

### 3. Conclusions

Emphysematous pancreatitis is a potentially life-threatening condition. The initial clinical manifestation may be insidious, but rapid progression to sepsis will occur in the absence of early therapeutic intervention. Conventional radiography and ultrasonography are often the initial imaging modalities used to evaluate patients with abdominopelvic complaints. These modalities should be considered complementary, each with strengths and limitations. When a differential diagnosis re-mains, CT should be considered the imaging modality of choice. CT is both highly sensitive and specific in the detection of abnormal gas and well suited to reliable depiction of the anatomic location and extent of the gas. Therefore, with regard to emphysematous pancreatitis, appropriate radiologic evaluation combined with accurate interpretation of findings will help to ensure rapid diagnosis and optimal treatment planning. In addition, knowledge of the pathophysiologic characteristics and common predisposing conditions associated with gas-forming infections of the gallbladder, stomach, pancreas, and genitourinary system will aid in further diagnostic work-up, surveillance of potential complications, and evaluation of therapeutic response. The prognosis for emphysematous pancreatitis is grave, and successful treatment requires aggressive management of the infection with systemic antimicrobial therapy and control of septic shock. Early surgical debridement is usually performed, and recovery is typically prolonged.

### 4. Acknowledgment

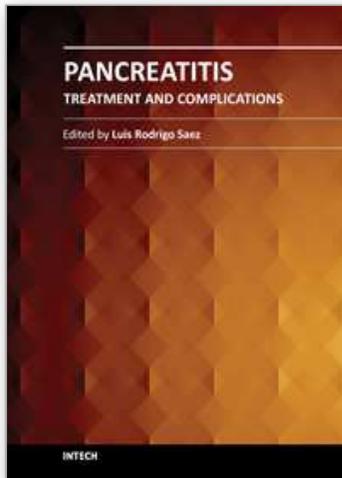
Emphysematous pancreatitis is a rare and life-threatening necrotizing infection of the pancreas - 2% of all acute necrotic pancreatitis. CT is the modality of choice for detecting parenchymal gas as well as evaluating its extent and location. Ordinarily emphysematous pancreatitis requires urgent surgical management, which in most cases is successful, at the onset of disease due to multisystem organ failure and patient instability. In cases of emphysematous pancreatitis, pancreatic necrosis is already demarcated and organized at the first week, which is enough to repeat one or two additional necrosectomies for the patient full recovery. If the patient's condition is stable, aggressive broad-spectrum antibiotic coverage, nutritional support, and routine correlation of clinical progression with radiological evaluation must be taken. As demonstrated by our experience, if the patient's condition is stable, antibiotic treatment could be undertaken without any surgical intervention despite the evidence of pancreatic infection. General physical condition of the patient is an important factor for choosing a treatment rather than bacteriological or radiological findings of the infection. Aggressive broad-spectrum antibiotic coverage, nutritional support, and routine correlation of clinical progression with radiological evaluation were assets.

### 5. References

- Adler, D. et al. (2003). Conservative management of infected necrosis complicating severe acute pancreatitis. *American journal of Gastroenterology*, Vol. 98, No. 1, (January, 2003), pp. 98-103, ISSN 0002-9270.

- Anderson, C. et al. (2004). Pneumoretroperitoneum in two patients with *Clostridium perfringens* necrotizing pancreatitis. *The American surgeon*, Vol. 70, No.3, (March, 2004), pp. 268-271, ISSN 0003-1348.
- Barreiro-Pardal, C. et al. (2011). Therapeutic management of emphysematous pancreatitis. *Revista Española de Enfermedades Digestivas*, Vol. 103, No. 5, (May 2011), pp. 282-283, ISSN 1130-0108.
- Bazan, HA. Kim, U. (2003). Images in clinical medicine. Emphysematous pancreatitis. *The New England Journal of Medicine*, Vol. 25, No.12, (December 2003), pp. 349, ISSN 0958-3165.
- Birgisson, H. et al. (2001). Emphysematous pancreatitis. *European Journal of Surgery*, Vol. 167, No.12, (December 2001), pp. 918-920, ISSN 1741-9271.
- Buckley, O. et al. (2006). A case of emphysematous pancreatitis. *British journal of Hospital Medicine*. Vol. 67, No.9, (September 2006), pp. 495, ISSN 1750-8460.
- Camps, I. et al. (2009). VAC (vacuum-assisted closure) "covered" laparostomy to control abdominal compartmental syndrome in a case of emphysematous pancreatitis. *Cirurgia Espanola*, Vol. 86, No.4, (October 2009), pp. 250-251, ISSN 0009-739X.
- Choi, HS. et al. (2010). Simultaneous emphysematous cholecystitis and emphysematous pancreatitis: a case report. *Clinical Imaging* , Vol. 34, No. 3, (May-Jun 2010), pp. 239-241, ISSN 0899-7071.
- Daly, JJ. Et al. (1995). Emphysematous pancreatitis. *Radiographics*, Vol. 15, No.2, (March 1995), pp. 489-492, ISSN 0271-5333.
- Holdsworth, RJ. Parratt, D. (1996). The potential role of *Clostridium perfringens* alpha toxin in the pathogenesis of acute pancreatitis. *Journal of Clinical Pathology*, Vol. 49, No.4, (April 1996), pp. 500-503, ISSN 0021-9746.
- Ikegami, T. et al. (2004). Primary gas gangrene of the pancreas: report of a case. *Surgery Today*, Vol. 34, No.1, (January, 2004), pp. 80-81, ISSN 0941-1291.
- Fischer, MG. Geffen A. (1959). Emphysematous Necrotizing Pancreatitis. *Archives of surgery*, Vol. 79, No.10, (October 1959), pp. 567-569, ISSN 0004-0010.
- Ghidirim, G. et al. (2005). Emphysematous necrotizing pancreatitis. *Chirurgia (Bucur)*, Vol. 100, No.3, (May-Jun 2005), pp. 293-296, ISSN 1221-9118.
- Grayson, DE. Et al. (2002). Emphysematous infections of the abdomen and pelvis: a pictorial review. *Radiographics*, Vol. 22, No.3, (May-Jun 2002), pp. 543-561, ISSN 0271-5333.
- Kvinlaug, K. et al. (2009). Emphysematous Pancreatitis: A Less Aggressive Form of Infected Pancreatic Necrosis? *Pancreas*, Vol. 38, No. 6, (August, 2009), pp. 667-671, ISSN 1727-3048.
- Ku, YM. Et al , (2007). Medical management of emphysematous pancreatitis. *Journal of Gastroenterology and Hepatology*, Vol. 22, No.3, (March 2007), pp. 455-456, ISSN 1440-1746.
- Levy, P. et al. (1999). Spontaneous gas gangrene of the pancreas caused by *Clostridium perfringens*. *Gastroentérologie clinique et biologique*, Vol. 23, No.2, (March 1999), pp. 1223-1248, ISSN 0399-8320.
- Morris, DL. et al. (1993). Case report: emphysematous tuberculous pancreatitis diagnosis by ultrasound and computed tomography. *Clinical radiology*, Vol. 48, No.4, (October 1993), pp. 286-287, ISSN 0009-9260.
- Noorda, EM. Et al. (2002). A particular case of acute necrotizing pancreatitis. *Surgery*, Vol. 131, No.5, (May 2002), pp. 589-590, ISSN 1528-8242.

- Novellas, S. et al. (2009). CT imaging features and significance of gas in the pancreatic bed. *Journal de Radiologie*, Vol. 90, No. 2, (February 2009), pp. 191-198, ISSN 0221-0363.
- Porter, NA. Lapsia, SK. (2010). Emphysematous pancreatitis: a severe complication of acute pancreatitis. *Oxford journal of Medicine*, Vol. 10, No.8, (August 2010), pp. 1093 ISSN 1460-2725.
- Ramesh, H. et al. (2003). Are some cases of infected pancreatic necrosis treatable without intervention? *Digestive surgery*, Vol. 20, No. 4, (April, 2003), pp. 296-299, ISSN 0253-4886
- Sadeghi-Nejad, H. al. (1994). Spontaneous gas gangrene of the pancreas. *Journal of Clinical Gastroenterology*, Vol. 18, No.1, (February 1994), pp. 136-138, ISSN 0192-0790.
- Sodhi, KS. Et al. (2010). Emphysematous pyelonephritis with emphysematous pancreatitis. *The Journal of Emergency Medicine*, Vol. 39, No.12, (July 2010), pp. 85-87, ISSN 0736-4679.
- Stockinger, Z. et al. (2004). Pneumoperitoneum from gas gangrene of the pancreas: three unusual findings in a single case. *Journal of Gastrointestinal Surgery*, Vol. 8, No.4, (April, 2004), pp. 489-492, 1091-255X.
- Šileikis, A. et al. (2007). Experience of the Treatment of Emphysematous Necrotizing Pancreatitis. *Chirurgische gastroenterology*, Vol. 23, No. 2, (April, 2007), pp. 195-198, ISSN 0177-9990.
- Šileikis, A. et al. (2007). Three cases of emphysematous necrotizing pancreatitis treated by different methods. *Acta medica Lituanica*, Vol. 14, No. 2, (April 2007), pp. 108-110, ISSN 1392-0138.
- Verbeeck, N. et al. (2011). Exceptional, potentially fatal combination of emphysematous pancreatitis and gas-forming cholecystitis: successful multidisciplinary conservative treatment supported by repeated CT-staging. *Journal Belge de Radiologie - Belgisch Tijdschrift voor Radiologie*, Vol. 94, No. 2, (March-April 2011), pp. 71-74, ISSN 0302-7430.
- Velasco Guardado, A. et al. (2009). Emphysematous pancreatitis: Conservative or surgical treatment? *Journal of Gastroenterology and Hepatology*, Vol. 32, No.93, (November 2009), pp. 605-609, ISSN 1440-1746.
- Wig, JD. et al. (2008). Emphysematous pancreatitis. Radiological curiosity or a cause for concern? *Journal of the pancreas*, Vol. 8, No.2, (March 2008), pp. 160-166, ISSN 1590-8577.



## **Pancreatitis - Treatment and Complications**

Edited by Prof. Luis Rodrigo

ISBN 978-953-51-0109-3

Hard cover, 212 pages

**Publisher** InTech

**Published online** 02, March, 2012

**Published in print edition** March, 2012

Pancreatitis may be acute or chronic. Although they can be caused by similar aetiologies, they tend to follow distinct natural histories. Around 80% of acute pancreatitis (AP) diagnoses occur as secondary to gallstone disease and alcohol misuse. This disease is commonly associated with the sudden onset of upper abdominal that is usually severe enough to warrant the patient seeking urgent medical attention. Overall, 10 to 25% of AP episodes are classified as severe, leading to an associated mortality rate of 7 to 30%. Treatment is conservative and consists of general medical support performed by experienced teams, sometimes in ICUs. Although most cases of acute pancreatitis are uncomplicated and resolve spontaneously, the presence of complications has significant prognostic importance. Necrosis, hemorrhage, and infection convey rates of up to 25%, 50%, and 80% mortality, respectively. Other complications such as pseudocyst formation, pseudoaneurysm formation, or venous thrombosis increase morbidity and mortality to a lesser degree. The presence of pancreatic infection must be avoided.

### **How to reference**

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Audrius Šileikis (2012). Emphysematous Pancreatitis, *Pancreatitis - Treatment and Complications*, Prof. Luis Rodrigo (Ed.), ISBN: 978-953-51-0109-3, InTech, Available from:

<http://www.intechopen.com/books/pancreatitis-treatment-and-complications/emphysematous-pancreatitis>

**INTECH**  
open science | open minds

### **InTech Europe**

University Campus STeP Ri  
Slavka Krautzeka 83/A  
51000 Rijeka, Croatia  
Phone: +385 (51) 770 447  
Fax: +385 (51) 686 166  
[www.intechopen.com](http://www.intechopen.com)

### **InTech China**

Unit 405, Office Block, Hotel Equatorial Shanghai  
No.65, Yan An Road (West), Shanghai, 200040, China  
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元  
Phone: +86-21-62489820  
Fax: +86-21-62489821

© 2012 The Author(s). Licensee IntechOpen. This is an open access article distributed under the terms of the [Creative Commons Attribution 3.0 License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

IntechOpen

IntechOpen