

Gastric Pneumatosis With Portal Venous Gas Can Be Treated Non-operatively: a Retrospective Multi-institutional Study

Antoine Epin (✉ antoinepin9@gmail.com)

CHU Nord Saint Etienne, Avenue Albert Raimond

Guillaume Passot

Centre Hospitalier Lyon-Sud

Niki Christou

CHU Limoges: Centre Hospitalier Universitaire de Limoges

Olivier Monneuse

Groupement Hospitalier Édouard Herriot: Groupement Hospitalier Edouard Herriot

Jean-Yves Mabrut

Hospital Croix-Rousse: Hopital de la Croix-Rousse

Pierre-Alexandre Ferrero

CHU Limoges: Centre Hospitalier Universitaire de Limoges

Sebastien Caudron

CHU Limoges: Centre Hospitalier Universitaire de Limoges

Denis Pezet

CHU Clermont-Ferrand: Centre Hospitalier Universitaire de Clermont-Ferrand

Benoit Magnin

CHU Estaing

Rémi Grange

CHU Saint-Étienne: Centre Hospitalier Universitaire de Saint-Etienne

Céline Lambert

CHU Clermont-Ferrand: Centre Hospitalier Universitaire de Clermont-Ferrand

Nicolas Williet

CHU Saint-Étienne: Centre Hospitalier Universitaire de Saint-Etienne

Alexandros N. Flaris

CHU Lyon: Hospices Civils de Lyon

Bertrand Le Roy

CHU Saint-Étienne: Centre Hospitalier Universitaire de Saint-Etienne

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Abstract

Background: Gastric pneumatosis (GP) is a rare radiologic finding with an unpredictable prognosis. The aim of this study was to identify mortality risk factors from patients presenting with GP on computed tomography (CT), and to develop a model which would allow us to predict which patients would benefit most from operative management.

Methods: Between 2010 and 2020, all CT-scan reports in 4 tertiary centers were searched for the following terms: “gastric pneumatosis”, “intramural gastric air” or “emphysematous gastritis”. The retrieved CT scans were reviewed by a senior surgeon and a senior radiologist. Relevant clinical and laboratory data for these patients were extracted from the institutions’ medical records.

Results: Among 58 patients with GP portal venous gas and bowel ischemia were present on CT scan in 52 (90%) and 17 patients (29%), respectively. The 30-day mortality rate was 31%. Univariate analysis identified the following variables as predictive of mortality at the time of the diagnosis of GP: abdominal guarding, hemodynamic instability, arterial lactate level >2mmol/l, and absence of gastric dilatation. Multivariable analysis identified the following variables as independent predictors of mortality: arterial lactate level (OR: 1.39, 95% CI: 1.07 - 1.79) and absence of gastric dilatation (OR: 0.07, 95% CI: 0.01 - 0.79). None of the patients presenting with a baseline lactate rate <2 mmol/l died within 30 days following diagnosis, and no more than 17 patients out of 58 had bowel ischemia (29%).

Conclusions: GP could be managed non-operatively, even in the presence of portal venous gas. However patients with arterial lactate level>2mmol/l, or absence of gastric dilation should be surgically explored due to a non-negligible risk of mortality.

Background

Pneumatosis intestinalis is a radiological finding defined by the presence of gas in the intestinal wall currently associated with a severe ischemia of the bowel. In such a case emergency surgical exploration is warranted. Conversely, gastric pneumatosis (GP) is a little-known entity and to date is treated similarly to pneumatosis intestinalis when discovered on CT scan. GP can be the result of a wide range of benign and serious disease processes and prognosis varies [1–3]. Up to 20 different causes of GP have been reported in the literature such as perforated ulcer, nasogastric tube placement, caustic ingestion, increased intraluminal pressure, blunt trauma. Causes not related to the stomach have also been described such as superior mesenteric artery syndrome, chemotherapy, cholangiocarcinoma, biliary stent-related perforation, gangrenous cholecystitis, appendicitis, calciphylaxis [3–5]. An explanation could be that gas travels to the stomach from other areas along the alimentary tract wall. Emphysematous gastritis (EG) is also one of the causes of GP. It is a rare disease of the stomach caused by gas-forming bacteria. Only 80 reported cases of EG have been described in the literature [6, 7]. Recent studies have reported mortality rates of ~ 30 % whereas in older studies mortality reaches 60%. Conservative management (antibiotics) is the best way to treat EG [7, 8]. Due to the rarity of GP, it is very difficult to

distinguish the different etiologies of the disease, including EG. In this way, no difference of strategy is proposed and often an explorative surgery is mandatory as any pneumatosis intestinalis. An upper gastrointestinal endoscopy is sometimes performed to help decision-making by looking for a bacterial cause or signs of ischemia but is often non-contributory [8]. In order to avoid missing an ischemic event, an emergency explorative laparotomy is usually performed to check the viability of the stomach. In the literature, only case reports, reviews of the literature and small case series described gastric pneumatosis. The aim of this study was to identify mortality risk factors in patients presenting with GP on CT scan, and to develop a model which would allow us to predict which patients would benefit most from operative management.

Methods

Study design

This retrospective multi-institutional study included patients treated between January 2010 and January 2020. All CT reports of the participating centers were searched for the following terms: “gastric pneumatosis”, “emphysematous gastritis” or “intramural gastric gas”. All imaging was reviewed by a senior surgeon and a senior radiologist. The radiologist was blinded to the patients’ clinical information. Only patients with gastric pneumatosis on imaging confirmed by both the senior surgeon and radiologist were included in the study.

Data collection

Each patient’s clinical records were reviewed to extract demographic data and laboratory values. The following data were obtained: age, gender, body mass index (BMI), American society of anesthesiologists (ASA) score, history of smoking, history of diabetes mellitus, history of vascular disease, hemodynamic status (stable vs unstable), guarding of the abdomen, vomiting, lactate level, white blood cell count (WBC) and acute kidney failure (normal range: 62–106 mg/dL). Unstable hemodynamic condition was defined as the need for vasopressors to maintain a systolic arterial blood pressure over 90 mmHg at diagnosis. The presence or absence of the following imaging findings was recorded: portal venous gas, mesenteric venous gas, intramural bowel gas, gastric distention, free intraperitoneal gas and intra-abdominal fluid collection. Gastric distention was defined as a stomach with a diameter over 10 cm. Clinical and surgical management variables were also retrospectively analyzed. To determine the 30-day period, day 1 was defined as the day of the first CT scan when the diagnosis of GP was done. The anonymous data collection was supported by an ethical approval with ID IRBN702021/CHUSTE issued by the Institutional Review Board: IORG0007394.

Goals of the study

The main goal of this study was to determine which factors can accurately predict 30-day mortality. Candidate factors were clinical, laboratory and imaging findings. We also sought to determine which factors were associated with death among patients with gastric pneumatosis in the study.

Statistical analysis

Statistical analysis was performed using Stata software (version 15; StataCorp, College Station, Texas, USA). All tests were two-sided, with a Type I error set at 0.05. Categorical variables were expressed as frequencies and percentages, and quantitative variables as mean \pm standard deviation or as median [interquartile range], depending on whether the underlying distribution was normal or not respectively. Patients were compared according to their 30-day status (alive or dead) with the chi-squared test or the Fisher exact test for categorical variables and with the Student's t test or the Mann-Whitney test for quantitative ones. The Gaussian distribution was verified by the Shapiro-Wilk test and homoscedasticity by the Fisher-Snedecor test.

A sensitivity analysis was performed including only patients for whom lactate levels were available (data not shown). A multivariable analysis was implemented using a logistic regression, considering the covariates according to univariate results ($p < 0.05$) and clinical relevance: lactate level, gastric dilatation, hemodynamic instability and abdominal pain. The results were expressed as odds-ratio (OR) and 95% confidence interval (CI).

Comparisons according to the lactate level over or under 2 mmol/L were carried out as describe previously for the 30-day mortality. A receiver operating characteristic (ROC) curve was plotted to assess the ability of lactate level to predict 30-day mortality. The area under the ROC curve was presented with a 95% CI obtained with the technique of DeLong et al. [9]. To avoid missing out on gastric ischemia, a threshold was determined as the one which maximizes the sensitivity.

Results

Study population

Fifty-eight cases of patients with GP were included. Preoperative clinical data and lab values are summarized in Table 1. Portal venous gas was present in 52 patients (90%), small bowel pneumatosis in 14 patients (24%) and free intraperitoneal gas (22%) in 13 patients. Thirty-three patients were treated conservatively (57%).

Table 1

Preoperative clinical data, paraclinical data and management among the study population. Data are presented as frequencies (associated percentages), mean \pm standard deviation, or median [interquartile range]. ASA: American society of anesthesiologists; BMI: body mass index; CT: computerized tomography; WBC: white blood cell count.

	Patients (n = 58)
Male gender	37 (64%)
Age (years)	72 \pm 16
BMI (<i>n</i> = 34)	25.1 \pm 5.7
ASA score	
ASA 1	0
ASA 2	14 (24)
ASA 3	36 (62)
ASA 4	7 (12)
ASA 5	1 (2)
Tobacco	19 (33)
History of vascular disease	21 (36)
Diabetes mellitus	20 (34)
Clinical and biological presentation at baseline	
Hemodynamic instability	18 (31)
Abdominal defense	15 (26)
Vomiting	34 (59)
Renal insufficiency	27 (47)
Lactate (mmol) (<i>n</i> = 44)	2.55 [1.65; 7.8]
WBC (mmol)	13.7 [9.6; 21.0]
Paraclinical examinations	
CT-scan	58 (100)
Portal venous gas	52 (90)
Mesenteric venous gas	22 (38)

	Patients (n = 58)
Duodenal pneumatosis	19 (33)
Grelic pneumatosis	14 (24)
Gastric dilatation	51 (88)
Intra-abdominal effusion	19 (33)
Free intraperitoneal gas	13 (22)
Fibroscopy	18 (31)
Ischemia	9/18 (50)
Clinical management	
Surgery	25 (43)
Open surgery	20/25 (80)
Laparoscopy	3/25 (12)
Laparoscopy converted to open surgery	2/25 (8)
Explorative laparotomy without resection	17/25 (68)
Total gastrectomy	4/25 (16)
Small bowel resection	2/25 (8)
Clavien > 3	10/25 (40)

Among the 25 patients that were treated operatively, 5 (20%) were treated laparoscopically. Seventeen (68%) did not require any resection of their alimentary tract because no intraoperative signs of ischemia were found. For two patients, the ischemic lesions were too expanded for resection. Six (24%) patients required stomach or bowel resection: 4 underwent a total gastrectomy and 2 underwent small bowel resections. Medical and surgical management for both populations is presented in Fig. 1. Endoscopy was performed in 18 patients (31%); half of them (n = 9) had findings suggestive of ischemia (50%).

Among the 33 patients that were treated conservatively, 8 died on the day of diagnosis because of severe physiologic derangements. Twenty-five patients / 58 underwent surgery (43%). Fifteen patients out of 25 were alive at 30 days, and among them, 1 had gastrectomy and 2 had small bowel resection.

Furthermore, taking into account patients who died without surgery (8) and patients who presented an ischemia during surgery (9), we can consider that no more than 17 patients / 58 had bowel ischemia (29%).

Lactate levels

Figure 2 shows the ROC curve for lactate blood levels when predicting death at 30 days. There was no mortality at 30 days recorded for patients with a lactate level < 2 mmol/l. Table 3 compares patients with a lactate level ≤ 2 mmol/L (low lactate, $n = 20$ patients) and patients with a lactate level > 2 mmol/L (high lactate, $n = 24$ patients).

Among the low lactate level group, twelve patients were treated conservatively and all were alive on Day 30 after diagnosis. The remaining 8 patients underwent operative management. Of them, 7 were alive at 30 days and 6 of them had a negative laparotomy. Two patients had part of their alimentary tract resected during laparotomy: one died after a total gastrectomy and multi-organ failure at postoperative day (POD) 5, the other was alive after a small bowel resection for ischemia.

Thirty-day mortality among the high lactate group was 58% (14/24 patients). Ten patients / 24 did not have surgery and half of them (5) died on the day of hospital admission. Four of the 14 operated patients died of heart failure (no signs of ischemia), 2 had gastrectomy for ischemia, and 2 had too expanded ischemia. Six / 14 were alive at 30 days, four of them had no ischemia, one had gastrectomy and one had bowel resection.

Predictive factors of 30-day mortality

Forty patients (69%) were alive at 30 days, and 18 (31%) were dead. The univariate analysis of different prognostic factors with regards to mortality is summarized in Table 2. Higher lactate level, hemodynamic instability, abdominal pain and absence of gastric distention were significant predictors of mortality. In the multivariable analysis arterial lactate level remained significantly associated with 30-day mortality (OR: 1.39, 95% CI: 1.07 to 1.79), as well as gastric distention (OR: 0.07, 95% CI: 0.01 to 0.79).

Hemodynamic instability and abdominal pain were not significantly associated with 30-day mortality in the multivariable analysis.

Table 2

Preoperative data among patients alive and dead at 30 days. Data are presented as frequencies (associated percentages), mean \pm standard deviation, or median [interquartile range]. ASA: american society of anesthesiologists; BMI: body mass index; CT: computerized tomography; WBC: white blood cell count.

	Alive at 30-days (N = 40)	Dead at 30-days (N = 18)	P value
Male gender	23 (58)	14 (78)	0.14
Age (years)	71 \pm 16	74 \pm 17	0.42
BMI (<i>n</i> = 26/8)	25.3 \pm 6.2	24.3 \pm 3.8	0.55
ASA score > 2	29 (73)	15 (83)	0.51
Tobacco	12 (30)	7 (41)	0.41
Vascular disease	16 (40)	5 (28)	0.37
Diabetes mellitus	14 (35)	6 (33)	0.90
Clinical and biological presentation at baseline			
Hemodynamic instability	6 (15)	12 (67)	< 0.001
Abdominal pain and defense	7 (18)	8 (44)	0.050
Vomiting	25 (63)	9 (50)	0.37
Renal insufficiency	16 (40)	11 (61)	0.14
Lactate (mmol) (<i>n</i> = 29/15)	1.8 [1.5; 2.7]	8.2 [5.4; 10.0]	< 0.001
WBC (mmol)	12.4 [9.3; 23.0]	15.0 [10.0; 19.6]	0.65
Imaging presentation on the baseline CT-scan and fibroscopy			
CT scan			
Portal venous gas	36 (90)	16 (89)	1.00
Mesenteric venous gas	15 (38)	7 (39)	0.92
Duodenal pneumatosis	12 (30)	7 (39)	0.51
Grelic pneumatosis	8 (20)	6 (33)	0.33
Gastric dilatation	38 (95)	13 (72)	0.025
Intra-abdominal effusion	11 (28)	8 (44)	0.20
Pneumoperitoneum	9 (23)	4 (22)	1.00

	Alive at 30-days (N = 40)	Dead at 30-days (N = 18)	P value
Fibroscopy	14 (35)	4 (22)	0.33
Ischemia	7/14 (50)	2/4 (50)	1.00

Table 3

Pre-operative and management among patients with lactate over or under 2 mmol/L. Data are presented as frequencies (associated percentages), mean \pm standard deviation, or median [interquartile range]. ASA: american society of anesthesiologists; BMI: body mass index; CT: computerized tomography; WBC: white blood cell count.

	Lactate \leq 2 (n = 20)	Lactate $>$ 2 (n = 24)	P value
Dead at 30-days	1 (5)	14 (58)	< 0.001
Without surgery	0/12 (0)	6/10 (60)	0.003
With surgery	1/8 (40)	8/14 (57)	0.074
Male gender	12 (60)	16 (67)	0.65
Age (years)	67 \pm 17	72 \pm 18	0.39
ASA score $>$ 2	15 (75)	18 (75)	1.00
Vascular disease	10 (50)	7 (29)	0.16
Diabetes mellitus	7 (35)	9 (38)	0.86
Abdominal defense	3 (15)	9 (38)	0.095
Hemodynamic instability	3 (15)	14 (58)	0.003
WBC (mmol)	14.4 [8.3; 23.0]	16.0 [9.8; 22.5]	0.45
Portal venous gas	18 (90)	23 (96)	0.58
Duodenal pneumatosis	5 (25)	10 (42)	0.25
Grelic pneumatosis	3 (15)	10 (42)	0.054
Free intraperitoneal gas	3 (15)	7 (29)	0.31
Surgery	8 (40)	14 (58)	0.23

Discussion

In the present study, imaging, clinical and laboratory data of 58 consecutive patients who presented gastric pneumatosis on CT-scan, from 4 institutions, were included. Seventy percent of the 58 patients did not have gastric ischemia on further workup and 30-day mortality rate reached 31 %. Among all clinical, laboratory and imaging parameters, elevated lactate level and absence of gastric distention were significantly associated with 30-day mortality. Conversely, hemodynamic instability and abdominal guarding were not significant in multivariable analysis. All patients with a lactate under 2 mmol/L were alive at 30 days after the diagnosis of gastric pneumatosis. One patient with lactate level of 2 mmol/L died of complications of total gastrectomy in the early post-operative period (fistula). There was less gastric distention for patients dying at 30 days. This can be explained by the fact that gastric pneumatosis is the result of increased pressure inside the lumen of the stomach which causes extravasation of gas in the gastric wall without ischemia. Without gastric distention, the origin of gastric pneumatosis associated or not with portal venous gas could more often be due to ischemia and therefore be more serious. Pneumoperitoneum was present in 22% of the patients (n = 13). All these patients were surgically explored and only 1 patient presented a bowel perforation. In the remaining patients, pneumoperitoneum could probably be due to translocation of air through the stomach wall into the peritoneum. [8, 10]

Nine patients presented ischemia on endoscopy. Among them, five have been explored and only two presented ischemia requiring a gastrectomy. Endoscopy therefore seems to not add any diagnostic benefit. Portal venous gas on CT scan is a well-known sign of severity and usually leads to surgical management [10–12]. In this study, it was present in a large majority of patients (90%) and was not a mortality risk factor. Among the 25 patients with portal venous gas that underwent surgery, 16 (64%) had no signs of ischemia. This high proportion could be explained by the fact that GP is a poorly known radiological entity and even though its management mirrors that of intestinal pneumatosis, its prognosis is clearly different. Among alive patients at 30 days who underwent bowel resection, 1 had total gastrectomy and died the 40th postoperative day and 2 patients had small bowel resection. Therefore, surgery appeared to be beneficial for 2 out of 58 patients in this study (3.5%) and no patient benefited from gastrectomy. To date, the largest gastric pneumatosis cohort was published in 2014 by *Spektor et al.* with 24 patients included [13]. The main outcome was inpatient mortality. They reported, as this study does, a significant association between mortality and elevated lactate levels. Moreover, as reported here, mortality was not associated with portal venous gas or free intraperitoneal air. *Sharma et al.* in 2017 published a retrospective review of 17 patients with GP; most of the patients did not require a gastrectomy. Conservative management with a naso-gastric tube could be safely performed [14].

Our study's main strength is that this is the largest cohort of GP to assess the signs of severity and to describe the clinical and surgical management with its short- and long-term outcomes. The principal limitation is its retrospective nature, and therefore, when patients did not undergo surgery, it was difficult to determine whether death was due to gastric ischemia or was a consequence of other physiologic derangements.

Conclusion

Non-operative management of gastric pneumatosis found on CT scan even in the presence of portal venous gas or pneumoperitoneum is possible. In case of gastric dilatation associated with normal lactate level without abdominal pain and a stable hemodynamic state, a non-operative management could be undertaken.

Abbreviations

ASA: American society of anesthesiologists

BMI: body mass index

CI: Confidence interval

CT: Computed tomography

EG: Emphysematous gastritis

GP: Gastric pneumatosis

POD: Postoperative day

ROC: receiver operating characteristic

WBC: White blood cell count

Declarations

Ethics approval and consent to participate

The anonymous data collection was supported by an ethical approval with ID IRBN702021/CHUSTE issued by the Institutional Review Board : IORG0007394.

Consent for publication

All patients signed consent for publication

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests concerning this article

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Authors' contributions

AE, GP, BLR and AF: Design of the work.

NK, OM, JYM, PAF, SC, DP, BM, RG, NW: acquisition and analysis of the work

CL: interpretation of data

All authors have approved the submitted version (and any substantially modified version that involves the author's contribution to the study).

All authors have agreed both to be personally accountable for the author's own contributions and ensured that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature

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Figures

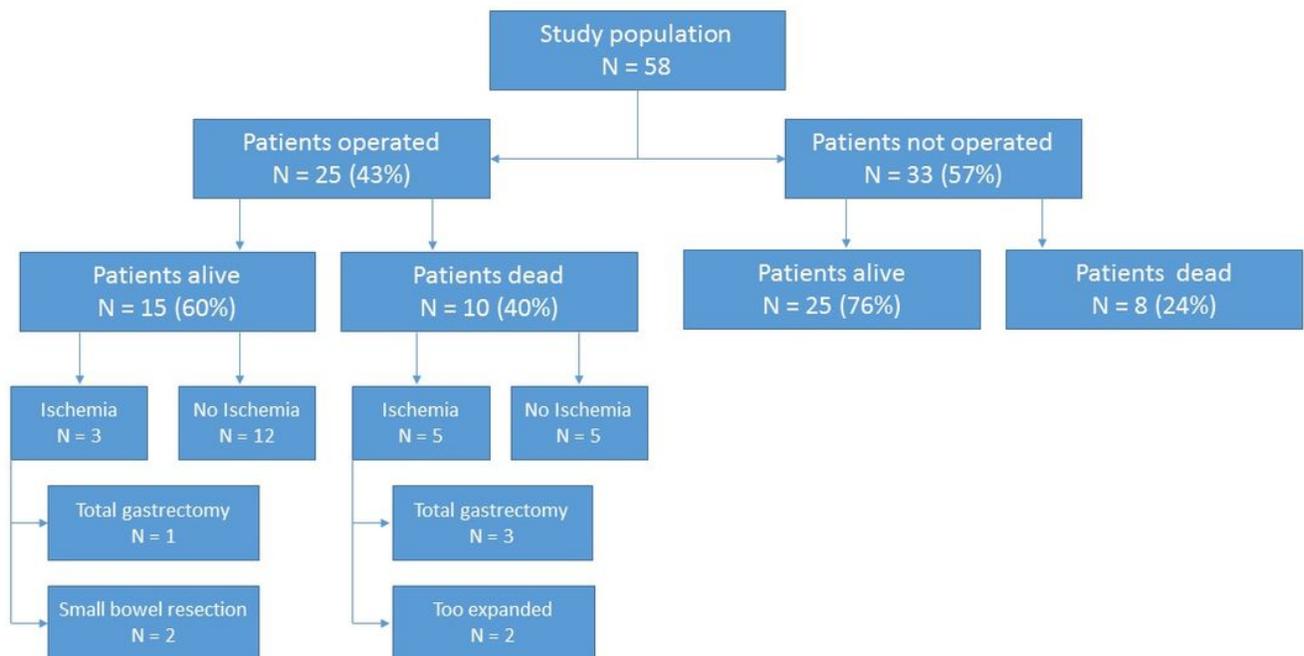


Figure 1

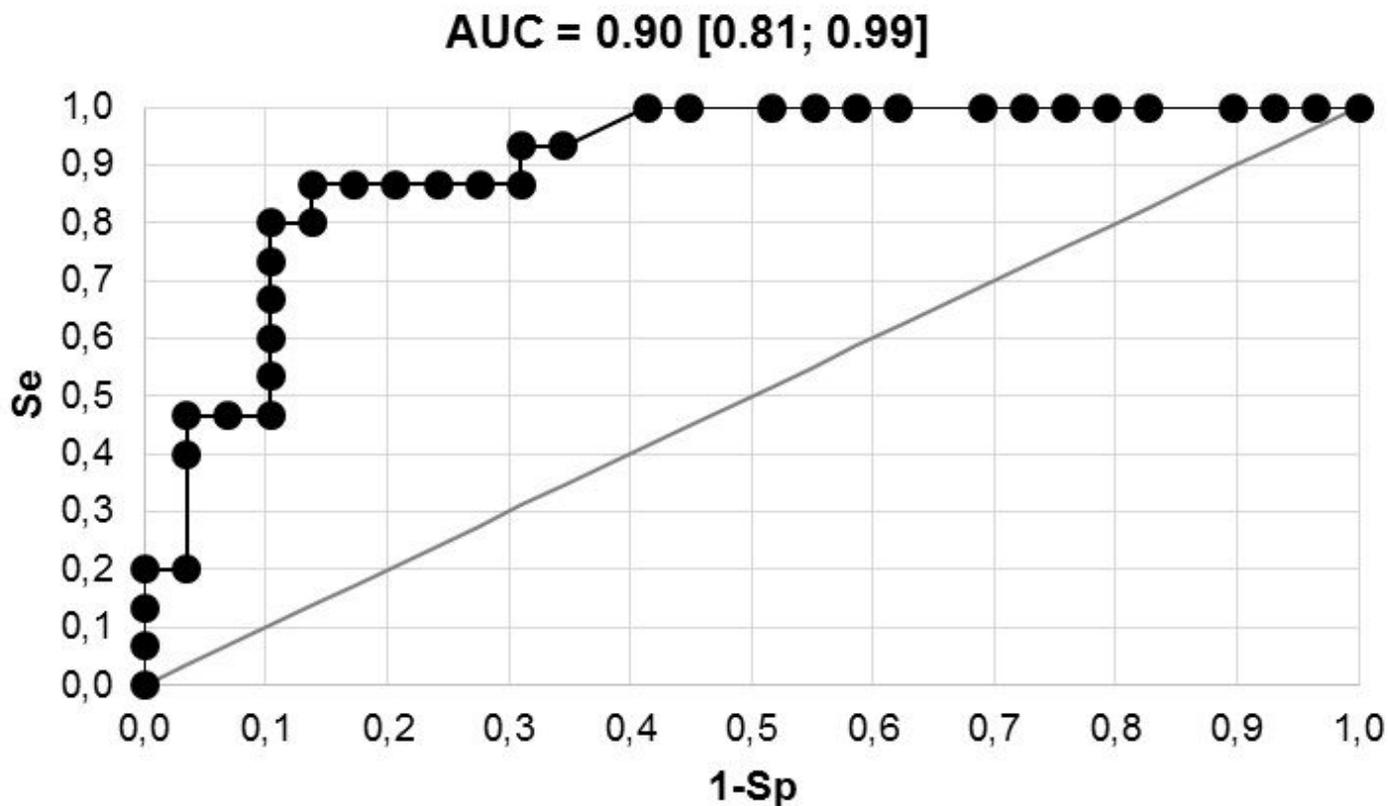


Figure 2

Receiver operating characteristic curve for performance of lactate in predicting death at 30 days. The area under the curve is presented with a 95% confidence interval. AUC: area under the curve; Se: sensitivity; Sp: specificity.