Ultrasound assessment of gastric volume in critically ill patients

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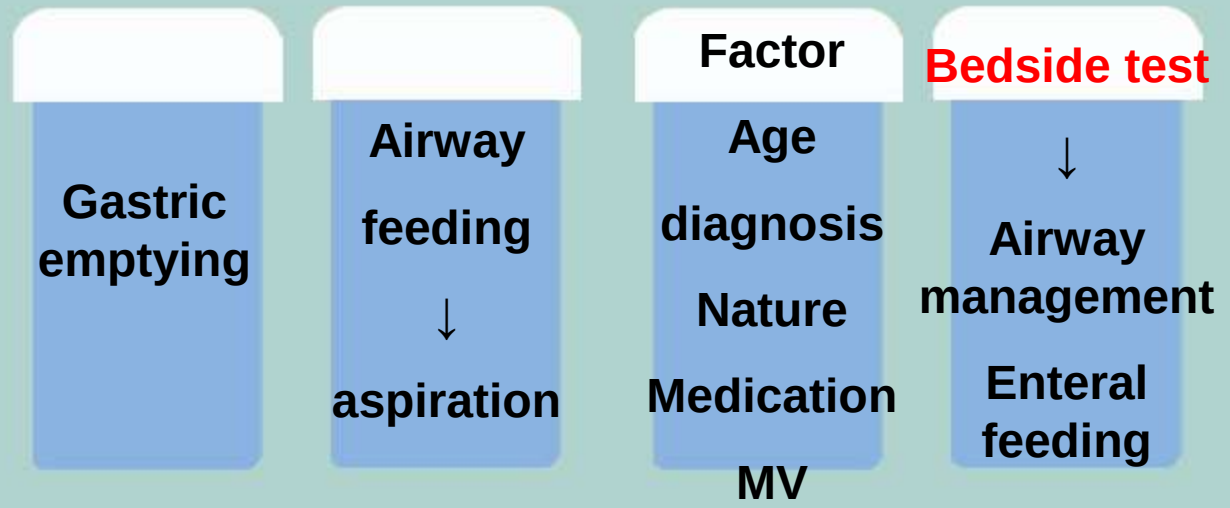
Introduction



Introduction

Healthy Volunteer

↓linear antral cross-sectional area (usCSA) and gastric volume

elective surgery

↓positive **usCSA and the fluid volume aspirated via a nasogastric tube**

critically ill patients?

↑

gastrointestinal dysfunction
positive-pressure ventilation

Gold standard

NO

Multiple-detector computed tomography（CT） （high spatial resolution） →Volumetric measurement by tomodensitometry

Aim

Feasibility and validity of ultrasound (US) to assess usCSA to predict gastric volume in critically ill patients

Reference method :use CT volumetric measurement

Materials and methods

Prospective observational study

18-bed academic intensive care unit

Local institutional review board

Informed consent

Protocol design

All consecutive patients admitted to the ICU→abdominal contrast-enhanced CT scan （prospectively and consecutively ）

Exclusion criteria：＜18y，pregnancy,and any medical history of upper gastrointestinal surgery

Clinical items：age, gender, body mass index, relevant medical and surgical history, reasons for ICU admission, length of stay in the ICU before inclusion in the study, and the indication for an abdominal CT scan.

SAPS II（A simplified acute physiology score）：on the day of inclusion

ISS（injury severity score）：multiple-trauma patients

The type of ventilation, ongoing medications, and all data regarding feeding were recorded (type of feeding, type of nasogastric tube, fasting time).

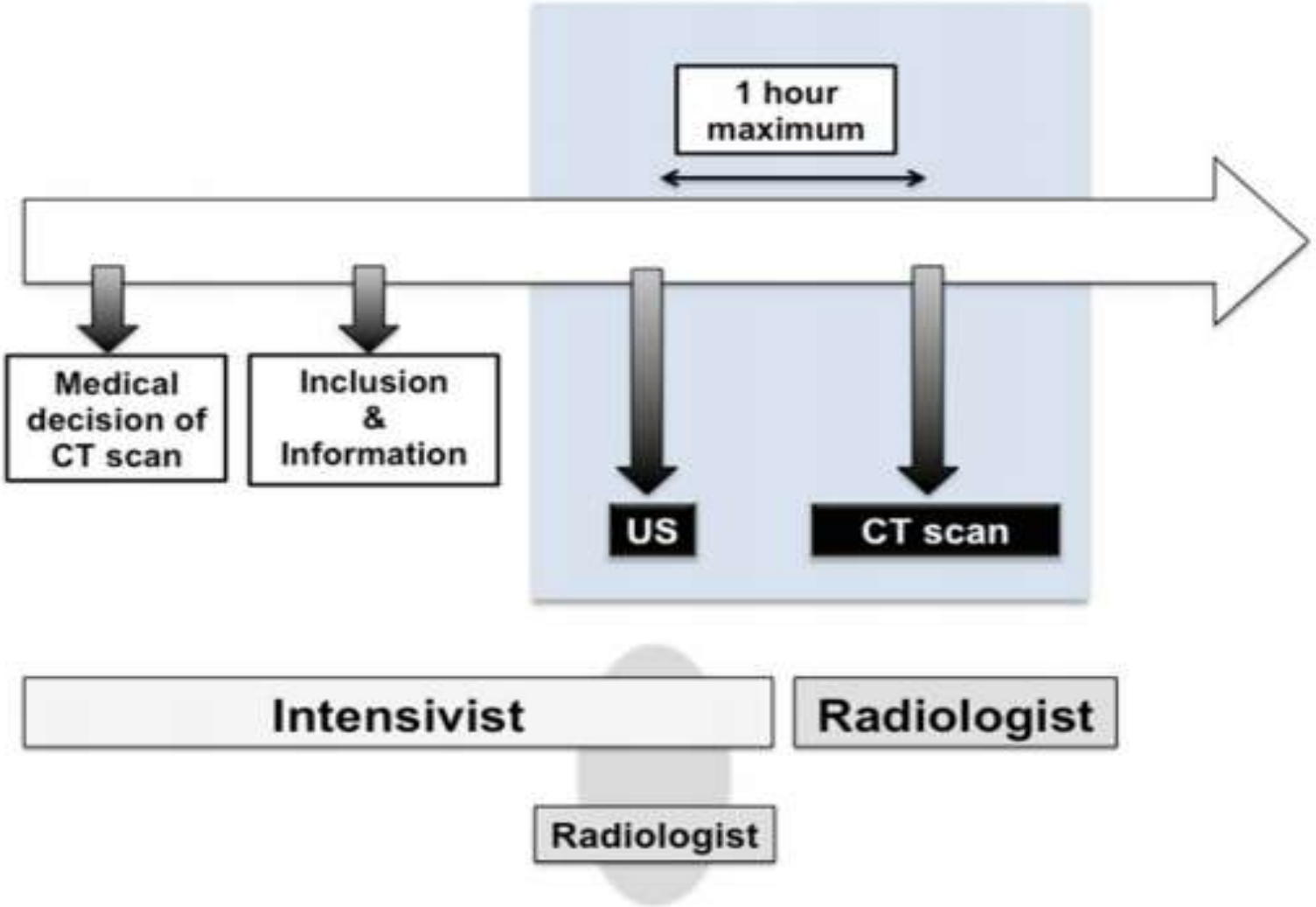


Fig. 1 Protocol design. *US* ultrasound, *CT scan* contrast-enhanced computed tomography

Standardized performance of ultrasonography

- US measurements： two experienced intensivists (PG) and (SH), who had undergone 4 h of practical training (12 cases), and an abdominal radiologist (MR)
- 60 min before undergoing an abdominal CT scan
- Semi-upright position： head 30°
- Antrum position: curvilinear probe in a parasagittal plane in the epigastric area

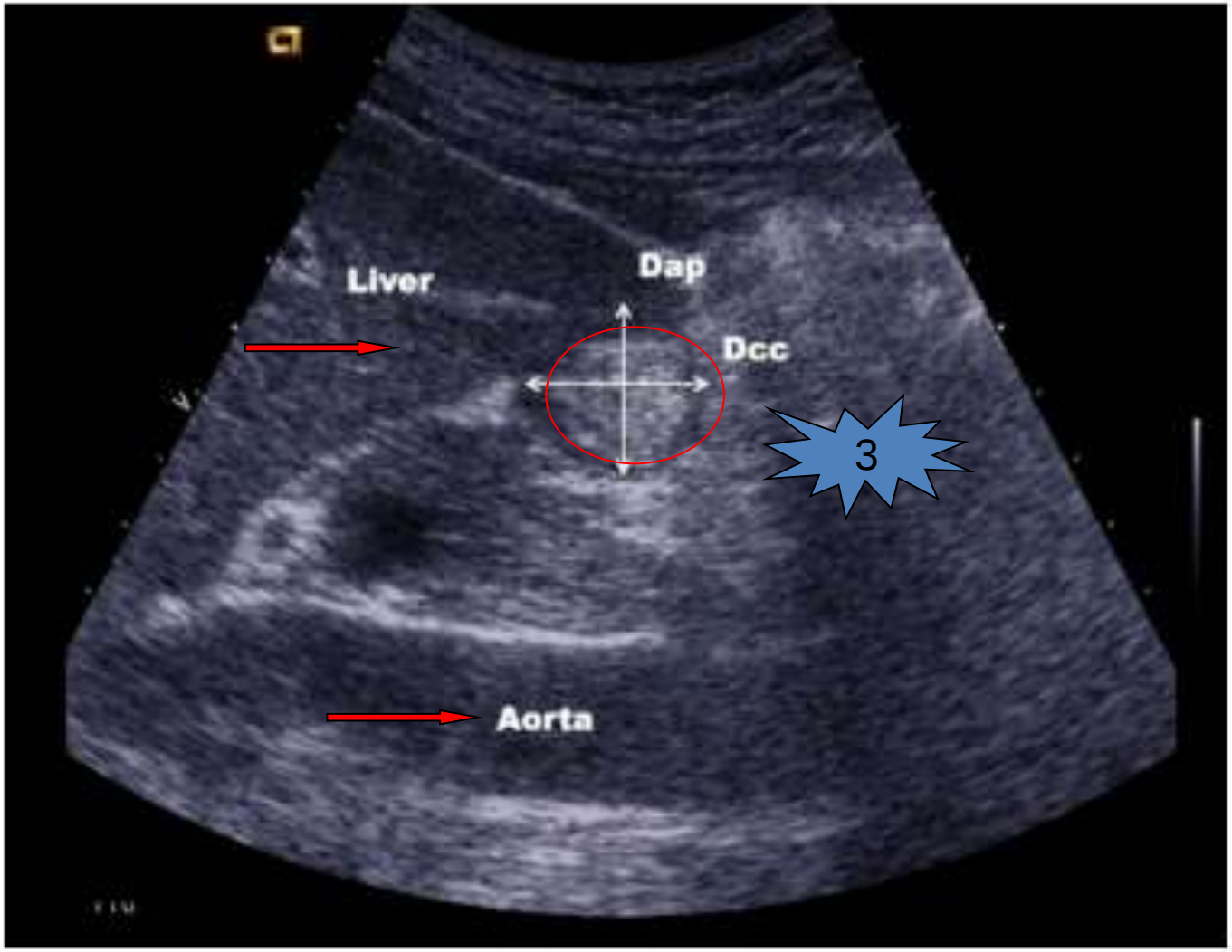


Fig. 2 Example of ultrasonographic image obtained for antral measurements in bidimensional mode. *Dap* anteroposterior diameter, *Dcc* craniocaudal diameter

NOTE:

Good

Poor

Impossible

nasogastric tube

usCSA=(mean Dap×mean Dcc×π）*/*4

Methods used for CT scan measurements

- 64-row detector CT
- Data： a dedicated workstation
- MR using semiautomatic dedicated software
- Blind
- Portal phase
- Three-dimensional technique: antral cross-sectional area (ctCSA), total gastric volume (air and fluid: GV total), and fluid volume alone(GV fluid).
- Mean of these three measurements
- ‘ ‘at-risk stomach’’were defined as those with a total gastric volume exceeding 0.8 mL/kg

Endpoints

- Primary endpoint :validity of the ultrasound technique, used by ICU physicians, predict gastric volume →US VS. CT
- Secondary endpoints: feasibility, cutoff value of an ‘‘at-risk stomach’’

Statistical analyses

- categorical variables→frequencies and percentages， Fisher’s exact test
- quantitative variables →medians (25–75th percentile)
- Kolmogorov–Smirnov test →whether continuous data were normally distributed
- Nonparametric Spearman’s correlation coefficient →Interdependence of US and CT
- logistic regression model →associations between the patients’ characteristics and gastric volume
- continuous variables → Wilcoxon’s rank-sum test

Statistical analyses

- intraclass correlation coefficient→measure intraobserver variability of the intensivists to measure usCSA
- ROC and ROCAUC →The performance of usCSA to discriminate an ‘‘at-risk stomach’’
- All tests were two-tailed and statistical significance was set at the $p < 0.05$ level.
- All analyses were performed using R software version 3.02 .

Table 1 Demographic and clinical characteristics of patients

Variables	Overall ($n = 55$)
Male, *n* (%)	47 (85.5 %)
Age (years)	50 [28; 61]
Weight (kg)	75 [65; 82]
BMI	23.9 [21; 26]
SAPS II	31.5 [17; 57]
ISS	23.5 [11; 57]
ICU LoS (days)	1 [1; 3]
Cause of ICU admission	
Major trauma, *n* (%)	27 (49 %)
Abdominal disease, *n* (%)	9 (16 %)
Miscellaneous, *n* (%)	19 (35 %)
History of abdominal surgery, *n* (%)	15 (27.3 %)
Nutrition	
Oral, *n* (%)	34 (62 %)
Enteral, *n* (%)	14 (25 %)
Fasting, *n* (%)	7 (13 %)
Mechanical ventilation, *n* (%)	28 (52 %)
US conditions	
Good	36 (65 %)
Poor	16 (29 %)
Impossible	3 (6 %)
Vasopressors, *n* (%)	12 (22 %)
US/CT time interval (min)	31 [23; 44]
US measurements of antral diameters	
Dap (mm)	27 [14.5]
Dcc (mm)	23 [10.5]
usCSA (cm^2)	4.5 [4.3]
CT measurements of antral diameters	
Dap (mm)	42 [17.5]
Dcc (mm)	30.5 [13.2]
ctCSA (cm^2)	9.9 [8.7]

ileus and gas screen

Continuous data are expressed as median [Q1; Q3]
SAPS simplified acute physiology score, *ISS* injury severity score, *ICU* intensive care unit, *LoS* length of stay, *SD* standard deviation, *US* ultrasonography, *CT* computed tomography, *Dap* anteroposterior diameter, *Dcc* craniocaudal diameter, *CSA* cross-sectional area

	All conditions (n=52)	Good conditions (n=36)	Bad conditions (n=16)
usCSA / GV Total	**0.39**	**0.43**	**0.14**
usCSA / ctCSA	0.47	0.48	0.48
usCSA / GV Fluid	0.33	0.38	0.18
ctCSA / GV Total	0.58	0.48	0.75
ctCSA / GV Fluid	0.48	0.46	0.3

usCSA ultrasonography of antral cross sectional area,
ctCSA computed tomography measure of antral cross sectional area,
GV gastric volume measured on the CT scan

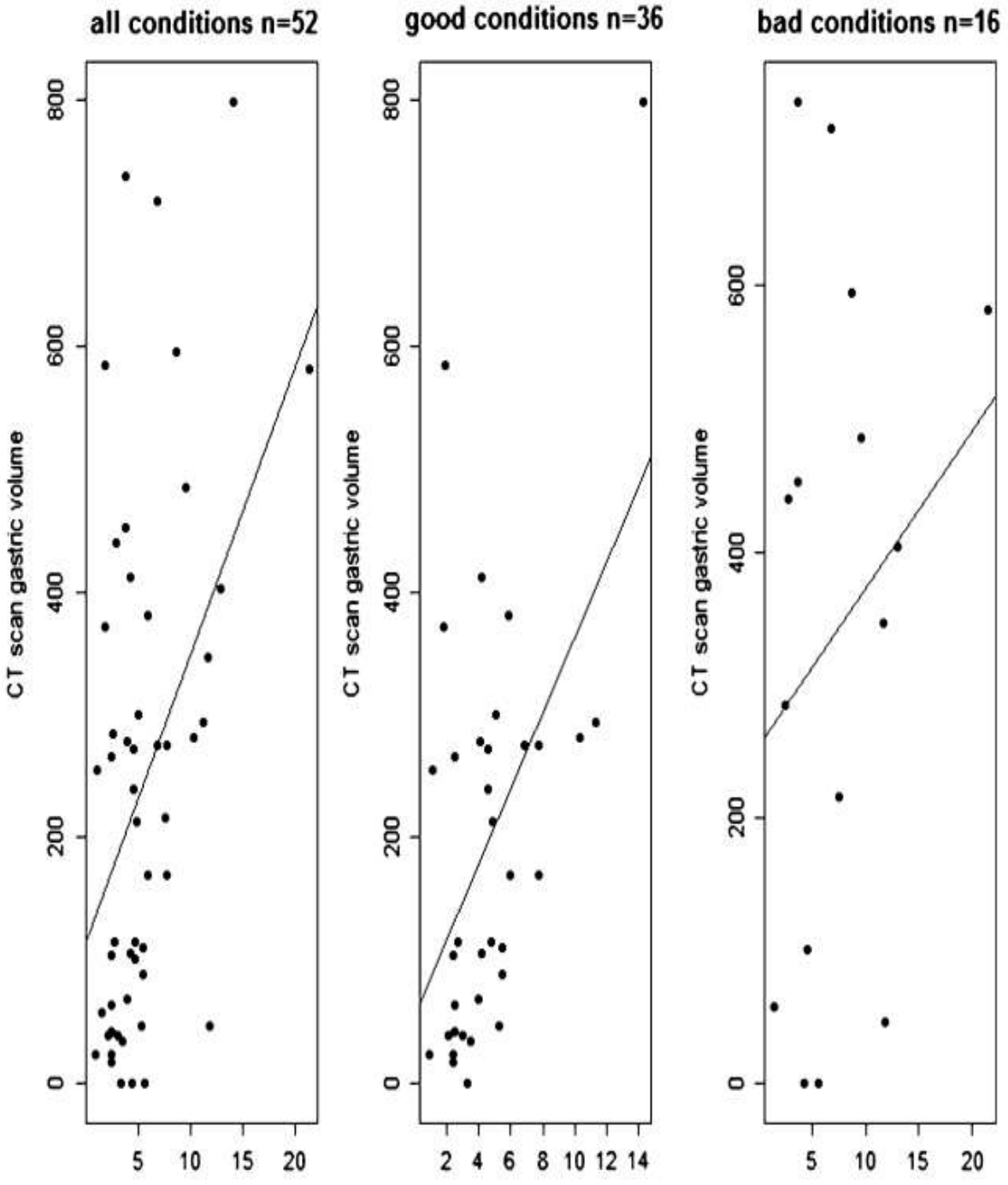
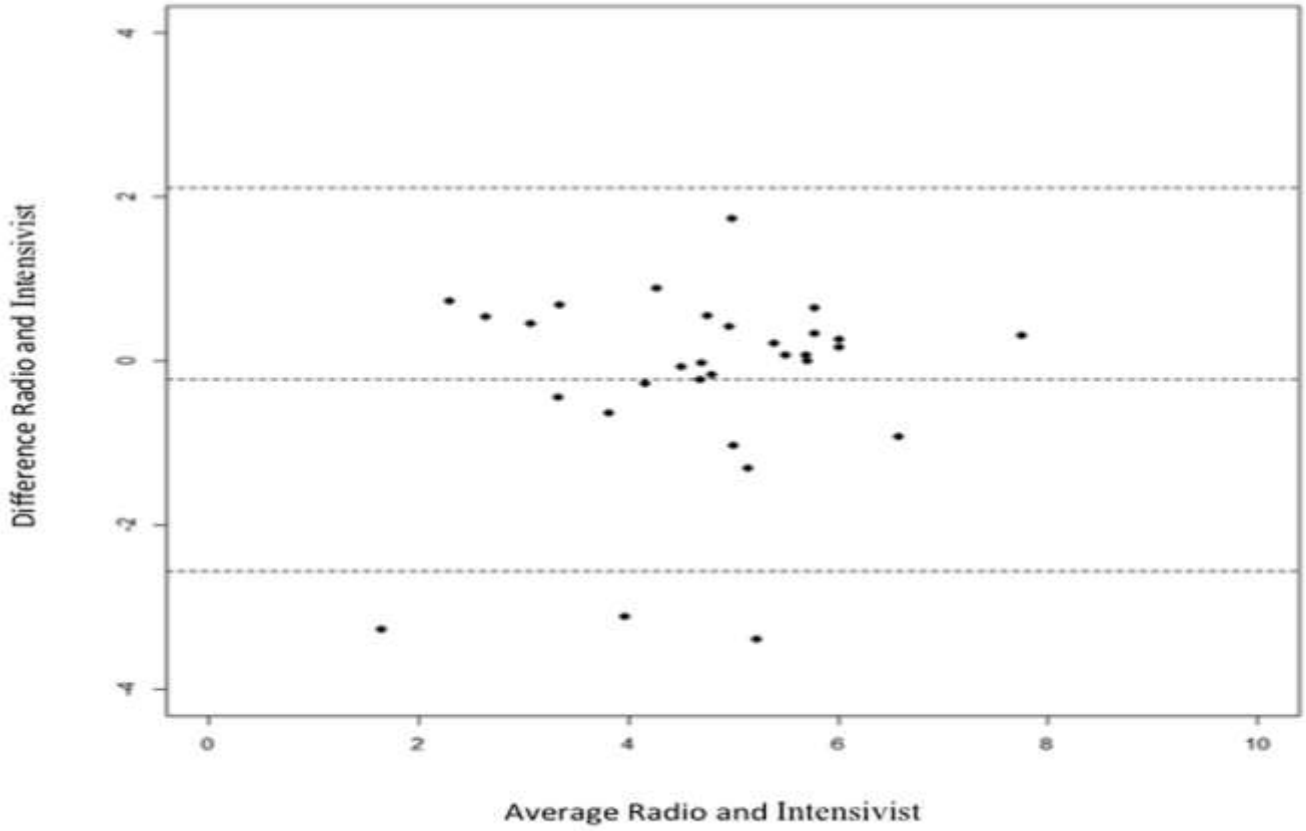


Fig. 3 Correlations between usCSA and CT total gastric volume in different conditions ("all" $\rho = 0.39$; "good" $\rho = 0.43$; and "bad" $\rho = 0.14$)

Results

- The logistic regression model did not show any significant association between gastric volume and age, gender, body mass index, mechanical ventilation, or vasopressor infusion.
- Intraobserver reproducibility of ICU physicians：intraclass correlation coefficient→0.97 (95 % CI 0.96–0.99)
- External validity:agreement between intensivists and radiologists was analyzed in 11 patients (20 %) (9 were ‘‘good’’ and 2 were ‘‘poor’’ conditions), leading to 30 pairs of measurements.



The Bland–Altman diagram estimated the systematic bias between usCSA measurements made by intensivists and radiologist at –0.12 cm^2 with limits of agreement of [–2.21; 1.96]
All measurements outside the
limits of agreement were obtained from measurements
performed in ‘‘poor’’ conditions.

‘ ‘at-risk stomach”, defined as a gastric volume exceeding 0.8 mL/kg, showed an area under the ROC curve of 0.799

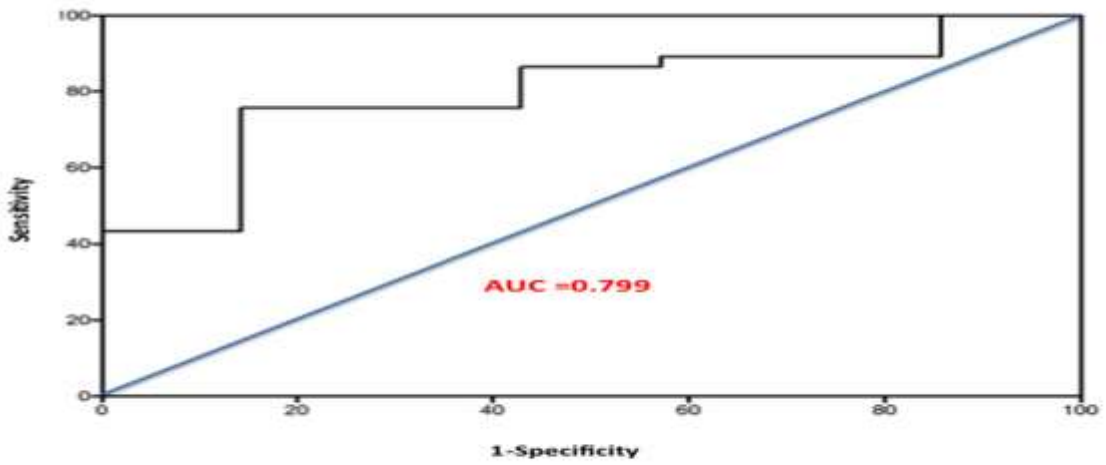


Table 2 Cutoff values of antral CSA measured by ultrasound to determine gastric volume, and performance of the test

Gastric volume (mL/kg)	usCSA (cm^2)	Sensitivity (%)	Specificity (%)
Total >0.4	2.45	86.6	100
Total >0.8	3.6	76	78
Fluid >0.4	3.9	72	82
Fluid >0.8	4.21	66	67

usCSA ultrasonography of antral cross-sectional area

Results

- Thirty-five nasogastric tubes out of 38 (92 %) were seen during the ultrasound examinations, of which 23 (60 %) were performed in ‘‘good’’ and 15 (40 %) in ‘‘poor’’ conditions.

DISCUSSION

- The main original finding:
- feasible;
- positively correlated; more strongly correlated in good conditions
- adequate measurements can be obtained in 65 % of cases (‘‘good’’conditions)
- ‘ ‘at-risk’’ stomach, defined as a gastric volume exceeding 0.8 mL/kg, and an ‘‘empty stomach’’ using a cutoff value for usCSA of 3.6 cm2

DISCUSSION

- The correlation between ultrasound and CT was not particularly strong
- Dynamic bedside test :how is enteral nutrition tolerated, does the patient need propulsant? medication, or should a gastric tube be placed prior to intubation?

DISCUSSION

- Internal repeatability was good and external validity showed a clinically acceptable bias.
- the five pairs of measurements with the highest negative differences made by the intensivists and the radiologist were obtained in ‘‘poor’’ conditions.
- If one only considers measurements realized in ‘‘good’’ conditions as reliable, this observation allowed us to conclude that external validity was excellent (Spearman’s ratio 0.94 and bias –0.08).

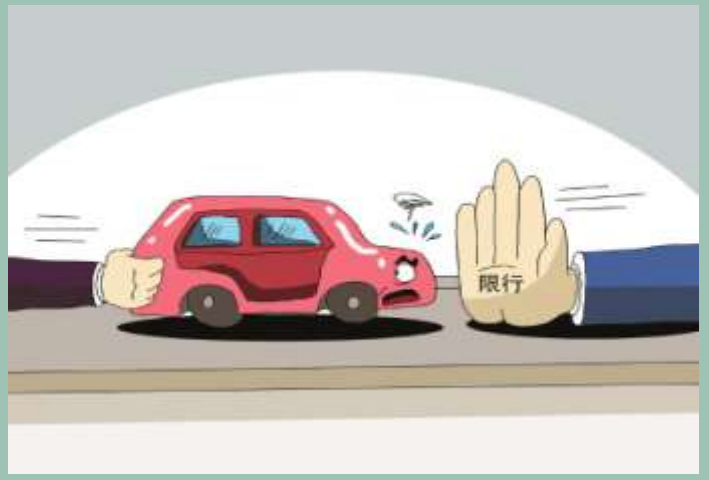
About Gold standard

- scintigraphy, gastric impedance or paracetamol absorption→ not accurate invasive and difficult to perform in critically ill patients.
- Aspirated through a nasogastric tube and then controlled, with a second US.
- Using a CT scan and ingested contrast agents

About Gold standard

- In our patients
- 64-row detector contrast-enhanced CT scan and three-dimensional semiautomatic volumetric analyses
- No oral contrast agent

limitations



- limited size.
- Gender disproportion :Male
- ‘at-risk stomach’’: primates
- aspiration of residual gastric volume through an enteral feeding tube was not part of our protocol.
- different types and different sizes of enteral feeding tubes

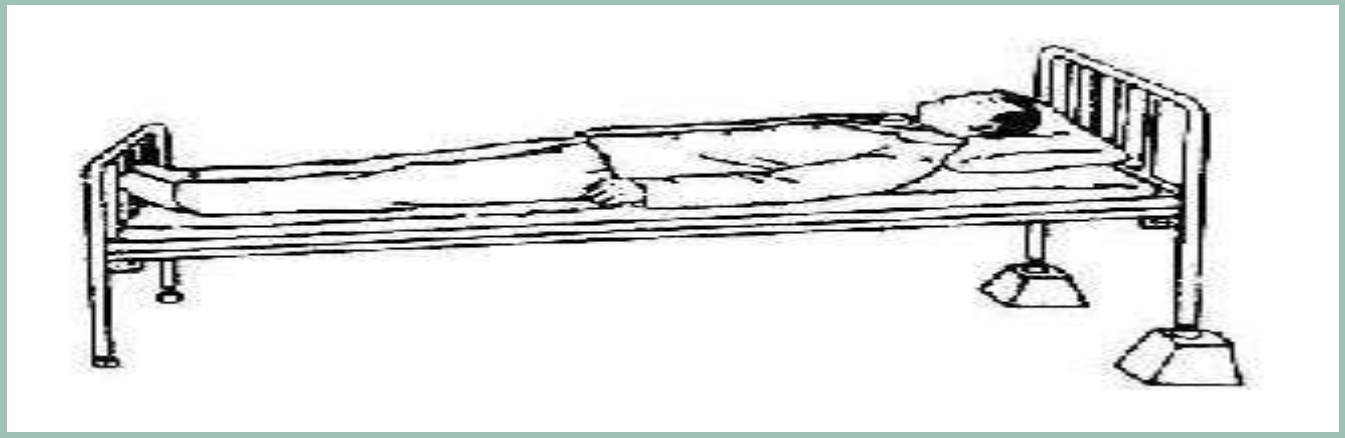
limitations

- we could see the nasogastric tubes in the stomachs of 92 % of the cases, suggesting that positioning of the nasogastric tube with US could possibly replace the standard abdominal radiographic technique.

- Another noteworthy point is that no learning curve was assessed in our study.

limitations

- we could not position all patients in the ideal semi-upright position because of orthopedic contraindications.(n=18)
- Measurements were not performed in the right lateral decubitus position.



Conclusion

- Antral cross-sectional area measured by ultrasound is feasible in the majority of critically ill patients.
- Antral CSA is positively correlated with gastric volume and allows qualitative assessment of gastric volume with clinically acceptable accuracy.
- Even though obtaining a usCSA is sometimes impossible in critically ill patients, the technique is still promising.
- It may help to assess gastric status before an emergency airway procedure with aspiration risksor trigger appropriate medications when enteral feeding is not well tolerated.

Conclusion

- Further studies and a higher number of patients are needed to confirm the results of this pilot experience.


Thanks!