Ultrasonography as an integrated tool in clinical decision-making in the Emergency Department

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Abstract

The aim of this retrospective study was to identify the role of ultrasonography as a decision-making and screening tool in emergency patients with pathological changes. Material and method: The study was carried out for 28 months in the Emergency Department of the County Emergency University Hospital, Cluj-Napoca. An ultrasound examination was performed as part of the clinical algorithm within the first hour of treating non-critical patients after they had been triaged. The diagnostic decision based on the results of the ultrasound examination was compared with the final diagnosis on discharge from the Emergency Department. Results: In study were included 1565 patients with a mean age of 50.61±19.21 years. Ultrasound changes were detected in a statistically significant number of patients from all the examined subgroups (p≤0.002). The concordance between clinical and ultrasound findings was of 54.06%. Of all the examined patients, 20.63% were referred to surgery department based on the results of the ultrasound examination. Surgery was the final therapeutic decision in 5.06% of all the patients with normal ultrasound findings. Conclusions: Ultrasonography as an integrated tool in the clinical examination algorithm allowed the identification of non-critical patients who required emergency surgery (20.63%). The integration of point-of-care ultrasound into the clinical examination allows the management of emergency patients through the ranking of decisions: hospital admission for surgery and medical treatment, other diagnostic investigations, referral to outpatient care and family physician.

Keywords: ultrasonography, emergency medicine, syndrome, clinical decision-making.

Introduction

Emergency medicine is a high-risk field when it comes to diagnostic errors or delayed treatment initiation. The large number of patients resulting in reduced examination times, often coupled with lack of access to the patient’s history, hinders the early detection of acute conditions with high morbidity and mortality, especially when the clinical picture is non-specific. Bedside ultrasound (US) allows rapid point-of-care evaluation guided by previously identified clinical signs and symptoms for the early diagnosis of conditions that require surgery or immediate care [1]. In 2001, the American College of Emergency Physicians introduced emergency US guidelines in order to increase the quality of diagnosis and follow-up, as well as to avoid diagnostic or treatment errors [1]. Thus, the following were defined as clinical contexts in which US examinations are indicated: during resuscitation, for diagnostic purposes, within clinical algorithms guided by sign/symptom, for guiding invasive procedures or monitoring emergency treatment and hemodynamic/ respiratory status. Emergency US is a direct examination focusing on the detection of a sign/symptom/syndrome for the diagnosis of life-threatening conditions that require immediate treatment [1]. The portable and non-radiating character of US machines used for clinical bedside examinations transforms them into a visual stethoscope that is able to determine
whether the patient has fluid accumulation/inflammatory process/complicated stones/venous thrombosis. Appropriate imaging training is required in order to reduce operator errors. Clinical evidence gathered for the past 15 years has allowed the inclusion of US examinations into the diagnostic and treatment algorithms for acute appendicitis, aortic aneurysms, acute heart failure, closed abdominal trauma, etc [1-5]. All these led to the introduction of basic training in US for the management of clinical problems in diagnostic and treatment algorithms [6].

Emergency US examinations provide morphological and functional information for patients’ monitoring. Equipping Romanian emergency services with US machines has allowed their introduction in current emergency practice, provided that adequate training can also be supplied.

The aim of this study was to identify the role of ultrasonography as a decision-making and screening tool in emergency cases with pathological changes with the purpose of reducing the incidence of diagnostic and treatment errors and improving adequate patient flow.

Material and method

A retrospective study was carried out between October 2011 and January 2014 in the Emergency Department (ED) of the County Emergency University Hospital of Cluj-Napoca. This regional medical unit with out-of-hospital CT examination facilities serves patients over 14 years of age with all acute pathologies. US examinations were performed by a specialist with 12 years’ experience in general US, as part of the clinical examination algorithms, 6 shifts of 12 hours per month. The examinations were conducted within the first hour of treating non-critical patients after the patients had been triaged and were guided by a previously-identified clinical syndrome. The diagnostic decision based on the US examination was compared with the final diagnosis at discharge from the emergency unit.

The inclusion criteria were as follows: non-critical patients over the age of 14, who presented for triage with a clinical picture of: biliary and pancreatic emergencies (biliary dyskinesia, biliary colic, jaundice syndrome, acute pancreatitis, pain in the right hypochondrium), digestive emergencies (epigastric pain, pain in the right iliac fossa, abdominal pain, bowel sub- obstruction, hyper-emesis syndrome, diarrhea syndrome, acute gastroduodenitis), acute surgical abdomen, renal and urologic emergencies (renal colic, macroscopic hematuria, oliguria and anuria), vascular emergencies such as venous thrombosis, gynecologic emergencies, closed thoracic and abdominal trauma, other non-specific emergencies (anemia, fever, ascites).

The following exclusion criteria were applied: patients under 14 years of age, patients with hemodynamic and respiratory instability, polytrauma patients, or patients with other clinical pictures then specified.

A Fukuda Denshi Ultrasound Color Doppler UF-850XTD was used. The machine is fully digital; it has multi-function B/W ultrasound systems and three transducers: convex (2.5-5 MHz), linear (6-9 MHz) and sector (2.5-5 MHz). The protocol included serial examinations in order to detect the cause of a previously identified sign/symptom, to evaluate fluid accumulation in the peritoneal/pleural/pericardial space and to carry out serial examinations of abdominal organs and tissues in clinical syndromes that are difficult to diagnose in emergency practice (table I). During the 168 selected shifts for the study, we received in ED 8904 patients and we selected in our study 1565 adult patients according with the inclusion criteria.

<table>
<thead>
<tr>
<th>Clinical syndrome</th>
<th>Ultrasound examination</th>
<th>Aim of examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed thoracic and abdominal trauma</td>
<td>FAST, EFAST, general abdominal ultrasound</td>
<td>Fluid accumulation, free air, parenchyal and visceral lesions</td>
</tr>
<tr>
<td>Biliary and pancreatic emergencies</td>
<td>Serial ultrasound with visualization of the biliary tree, coupled with general abdominal ultrasound</td>
<td>To identify changes in the gallbladder, biliary ducts and pancreas</td>
</tr>
<tr>
<td>Digestive emergencies</td>
<td>Serial ultrasound of the digestive tube and general abdominal ultrasound</td>
<td>Parietal changes in the digestive tube, inflammatory processes and free intra-peritoneal air, stenosis or dilation of the digestive tube and fluid accumulation</td>
</tr>
<tr>
<td>Acute surgical abdomen</td>
<td>Serial ultrasound of the digestive tube and general abdominal ultrasound</td>
<td>Distended bowel without movements, parietal changes and the presence of free intra-peritoneal air</td>
</tr>
<tr>
<td>Renal and urologic emergencies</td>
<td>Serial ultrasound of the kidneys, urethra and urinary bladder</td>
<td>Renal stones and obstructive complications</td>
</tr>
<tr>
<td>Vascular emergencies such as venous thrombosis</td>
<td>Ultrasound of the venous region of the affected limb</td>
<td>Changes such as intravascular thrombosis and incompressibility</td>
</tr>
<tr>
<td>Gynecologic emergencies</td>
<td>Serial ultrasound of the uterus and ovary and general abdominal ultrasound</td>
<td>Complicated ovarian cysts, inflammatory processes or torsions</td>
</tr>
<tr>
<td>Other emergencies</td>
<td>General abdominal ultrasound</td>
<td>Abscesses, tumors and peritoneal fluid accumulation</td>
</tr>
</tbody>
</table>
The data was recorded in emergency patient records and then transferred into a database. Pathological images were stored as *.jpg and cine loop files. The patients signed an informed consent form before the investigation. In order to maintain patient confidentiality, the information was transferred into the study database by recording the electronic registration number assigned on admission to the emergency care unit. The study was approved by the Ethics Committee of the County Emergency University Hospital of Cluj-Napoca.

**Statistical analysis**

Statistical analysis was conducted according to the type of investigated data. Quantitative variables were summarized as median and interquartile ranges whenever data proved not to follow the normal distribution. Categorical data was reported as percentages and associated 95% confidence intervals calculated using an exact method [7]. The Kruskal-Wallis ANOVA test was applied in order to assess differences between groups whenever quantitative data did not follow the normal distribution.

The Z-test for proportions was used to compare groups on categorical data. Statistical analysis was conducted with the Statistica program (v. 8, StatSoft) and p-values lower than 0.05 were considered statistically significant.

**Results**

One thousand five hundred sixty five patients aged between 14 and 92 years with a mean of 50.61±19.21 years were included in the study, with significant differences within the group (Kruskal-Wallis ANOVA, p<0.0001). The demographic data and the frequency of clinical syndromes are detailed in table II. The highest percentage was represented by the biliary and pancreatic emergencies (36.10%), closely followed by the digestive emergencies (31.57%). Age proved to be significantly higher in subjects with acute abdomen. Patients from the urban area predominated in the studied group (66.58%). The analysis according to gender revealed the predominance of female patients for all types of emergencies, except for thoracic and abdominal emergencies, where male patients predominated, and for vascular emergencies, where no statistically significant differences were recorded.

Ultrasound changes were observed in a statistically significant number of patients in all the studied subgroups (p=0.002 for other syndromes; p-values for all other plots <0.0001. Significant concordance between clinical and ultrasound findings was observed (55-83%) in the clinical syndromes examined (54.05% of all patients, 72.3% of those with pathologic ultrasound findings, respectively), except for digestive emergencies, abdominal and thoracic trauma and other non-critical syndromes (0-33%). Surgery was recommended based on the ultrasound examination in 77.5% of the patients with acute surgical abdomen and in 34.5% of the patients with biliary and pancreatic emergencies, respectively, which accounts for 20.64% of all the patients examined (table III).

Although the need for other investigations was higher in patients with acute abdomen (65%) and thoracic and abdominal trauma (81%), it only represented a low percentage from the total number of patients who underwent ultrasound examinations (19.48%).

Significant co-morbidities were found in patients with positive ultrasound findings who presented with vascular emergencies (50%) and biliary and pancreatic emergencies, respectively (21%) (fig 1).

Normal US findings were observed in a reduced percentage of patients with acute abdomen (1.26%, 95% CI [0-4]), gynecologic emergencies (0.91%, 95% CI [0-5]), digestive emergencies (2.27%, 95% CI [8-11]) and other clinical syndromes (2.43%, 95% CI [1-4]) who required surgery (1.27% of all patients, 5.06% of all normal ultrasound findings, respectively).

The percentage of FAST positive was of 6.36% while the percentage of parenchymal lesions was of 8.18%, without significant differences (p=0.6334). Among those with parenchymal lesions, a significantly lower percentage also had other lesions (p<0.0001). Interventional therapy was required in 21.06% of subjects (95% CI [17.88-24.78]) with biliary and pancreatic emergencies. 5.56% (95% CI

<table>
<thead>
<tr>
<th>Clinical syndrome</th>
<th>Number of patients</th>
<th>Age (years)</th>
<th>Environmental origin (u/r)</th>
<th>Sex (f/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestive emergencies</td>
<td>494 (31.56)</td>
<td>47.79±19.20</td>
<td>68/32</td>
<td>63/37*</td>
</tr>
<tr>
<td>Gynecologic emergencies</td>
<td>38 (2.43)</td>
<td>30.68±12.18</td>
<td>76/24</td>
<td>100/0*</td>
</tr>
<tr>
<td>Vascular emergencies</td>
<td>36 (2.30)</td>
<td>57.36±15.88</td>
<td>67/33</td>
<td>53/47</td>
</tr>
<tr>
<td>Acute abdomen</td>
<td>40 (2.56)</td>
<td>61.38±19.10</td>
<td>45/55</td>
<td>68/33*</td>
</tr>
<tr>
<td>Renal and urologic emergencies</td>
<td>238 (15.20)</td>
<td>43.81±18.94</td>
<td>70/30</td>
<td>55/45*</td>
</tr>
<tr>
<td>Biliary and pancreatic emergencies</td>
<td>565 (36.10)</td>
<td>56.27±17.10</td>
<td>65/35</td>
<td>64/36*</td>
</tr>
<tr>
<td>Abdominal/thoracic trauma</td>
<td>110 (7.03)</td>
<td>47.10±19.50</td>
<td>67/33</td>
<td>38/62*</td>
</tr>
<tr>
<td>Other emergencies</td>
<td>44 (2.81)</td>
<td>59.77±19.46</td>
<td>66/34</td>
<td>61/39*</td>
</tr>
</tbody>
</table>

*p<0.003, u=urban, r=rural, f=female, m=male. Data are expressed in number (percent) or mean±standard deviation.
Ultrasonography as an integrated tool in clinical decision-making in the Emergency Department

Adela C. Golea et al

Although decisions in emergency medicine are based on anamnesis/the patient’s history, clinical and paraclinically examinations. US investigations can influence subsequent investigations or immediate treatment choices. Lichtenstein DA described “ten reasons” for the use of US in critical care: the differential diagnosis of acute respiratory failure, acute circulatory failure, cardiac arrest, assistance during venous access, assessing ARDS and ventilated lungs, finding the cause of fever, decreased radiation, practicing a holistic approach to the heart, practicing visual diagnosis in modern medicine [8]. In 2009, Donald Medd addressed a letter to the editor of the American Journal of Ultrasound in Medicine in which he stated that US, as an integral part of the physical examination, can increase the safety of medical practice and reduce healthcare costs through the early detection of potentially critical situations [9]. Three years later, Gillman and Kirkpatrick introduced the concept of portable US as the visual stethoscope of the 21st century and defined its usefulness as a clinical examination tool rather than as a diagnostic test [10].

As far as the age decades with the highest frequency of presentation to the ED are concerned, the literature describes an increased number of presentations in patients over 45 years of age, with a further increase over 85 years [11]. In our study, the average age was above 45 years in six subgroups, except for gynecologic, renal and urologic emergencies. We recorded a statistically significant higher number of female, similar with the over 20% difference registered by “Healthcare Agencies” in ED from the Unites States of America [10]. The high percentage of urban patients in our studied groups was also in accordance with the literature data [10].

An increased occurrence in non-differentiated digestive emergencies was also recorded in our patients, which, correlated with the available literature data (18% increase between 2006 and 2011 in the USA [12]) underlines the role of imaging investigations in the clinical examination. This is also supported by the increased percentage of pathological changes detected by US and the low clinical concordance between clinical and imaging findings, the US examination having modified the clinical diagnosis in 32% of patients. Montanari et al highlighted that the use of a “pocket ultrasound device in biliary disease” confirmed a suspected diagnosis in 77% of patients [13]. Similar results were obtained in our study, given that the US identified pathological changes in 87.08% of biliary and pancreatic emergencies and confirmed the clinical diagnosis in 72.04% of patients. Studies demonstrated the good specificity of US examinations for the detection of biliary lithiasis and its complications [14,15].

Table III. Pathological ultrasound findings

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Digestive emergencies</td>
<td>65.59</td>
<td>33.00</td>
<td>13.56</td>
<td>38.87</td>
<td>33.20</td>
</tr>
<tr>
<td>Gynecologic emergencies</td>
<td>73.68</td>
<td>55.26</td>
<td>13.16</td>
<td>23.68</td>
<td>23.68</td>
</tr>
<tr>
<td>Vascular emergencies</td>
<td>80.56</td>
<td>55.56</td>
<td>2.78</td>
<td>55.56</td>
<td>61.11</td>
</tr>
<tr>
<td>Acute abdomen</td>
<td>90.00</td>
<td>57.50</td>
<td>77.50</td>
<td>82.50</td>
<td>25.00</td>
</tr>
<tr>
<td>Renal and urologic emergencies</td>
<td>89.50</td>
<td>83.19</td>
<td>0.84</td>
<td>82.35</td>
<td>33.61</td>
</tr>
<tr>
<td>Biliary and pancreatic emergencies</td>
<td>87.08</td>
<td>72.04</td>
<td>34.51</td>
<td>80.53</td>
<td>24.42</td>
</tr>
<tr>
<td>Abdominal/thoracic trauma</td>
<td>19.09</td>
<td>0.00</td>
<td>10.00</td>
<td>10.91</td>
<td>10.00</td>
</tr>
<tr>
<td>Other emergencies</td>
<td>61.36</td>
<td>31.82</td>
<td>25.00</td>
<td>22.73</td>
<td>20.45</td>
</tr>
<tr>
<td>All plots</td>
<td>74.75</td>
<td>54.06</td>
<td>20.64</td>
<td>59.23</td>
<td>28.31</td>
</tr>
</tbody>
</table>

US-path= pathological changes detected; US–verify CDG=US verified clinical diagnosis; US–Surg=emergency surgical treatment required; US-Med=emergency medical treatment required; US-Other=US detected other pathological changes, but not emergencies. Data are expressed as percent with 95% confidence interval (% [95% CI]).
The strategy for diagnosing acute abdominal pain on presentation in the ED aims to diminish the number of missed diagnoses, to reduce examination times and to avoid patient radiation. Literature data shows that the use of the US as a first-line examination, followed by a CT scan in case of a negative or inconclusive finding represents the best solution, with only a 6% chance of losing emergency patients [16]. The results obtained in our study were in agreement with literature data as only 5.06% of the patients with normal ultrasound findings (2.27% of digestive emergencies; 2.43% of other syndromes) required surgery (1.27% of all patients) after complementary investigations were performed. Although the need for further investigations was higher in the subgroup of patients with acute abdomen (65%) and trauma (81%), overall it did not exceed 20%, which confirms the usefulness of the US as first-line examination for reducing times and radiation.

The novelty of our study lies in the analysis of US examinations as a rapid diagnostic and treatment tool in emergency cases compared to X-ray/CT/MRI examinations, which require time and specialized physicians. Thus, we found that in biliary emergencies/other syndromes, 34.51% versus 25% of patients were referred to surgery after US, which is in agreement with the literature data on emergency exploratory surgery for abdominal pain (24.1%) [17].

We evaluated the role of US in the early administration of medical treatment (antibiotics, anticoagulants, anti-inflammatory drugs, IV therapy) and observed that imaging findings led to medical treatment initiation in over 80% of patients with acute abdomen, biliary, renal and urologic emergencies. This result, which has to be confirmed by other published studies, proves the usefulness of US in early management of emergency patients.

Studies showed that the prevalence of pathological changes increases with age and co-morbidities, which are frequent causes of complications, thus further strengthening the need for emergency ultrasound examinations [18]. In our study, patients with co-morbidities presented a higher percentage of US changes compared with normal US (3-50% versus 0-6%, the extreme being represented by vascular emergencies with 50% vs. 6%). Hasani et al also showed that 41.3% of the patients with acute abdominal pain, who underwent an emergency ultrasound examination, had co-morbidities [19]. The percentage of normal US was 34% (39.3% in case of radiologist with experience) for acute nonspecific abdominal pain, concordant with the study’s Hasani and the errors were at a reduced rate (2.27%) in our study compared with theirs (7%) [19]. Literature data shows that experience and training in US examination (normal US – 34% for highly experienced emergency physician in our study, 51.3% for emergency physicians, 39.3% for radiologists) can improve the accuracy and usefulness of the method [19].

As far as the role of US as part of the clinical algorithm in patients with trauma and vascular emergencies was concerned, we identified a lower percentage of confirmed diagnoses compared with literature data: 6.36% FAST positive (15.10% [20] and 78% [21] when hypotension was present) and 5.56% (18% [22] - 24% [23]) for diagnosed deep vein thrombosis.

The accidental detection of other changes that can influence the patient’s evolution is another argument in favor of emergency ultrasonography. Soultati et al registered accidental detections in 28.2% of patients (up to 20% requiring further treatment), more frequent on abdominal level and in elderly patients [24]. In our study, accidentally detected ultrasound changes were of 10% (trauma subgroup) up to 61.11% (vascular emergencies subgroup), with an overall incidence of 28.31%, which highlights the importance of emergency US screening for the prevention of unfavorable outcomes.

Thus, the results of our study demonstrate the importance of US as a part of the clinical algorithm for confirming a suspected diagnosis, for guiding the diagnosis in the absence of specific clinical findings, for identifying patients who require immediate medical and surgical treatment or for detecting morphological and pathological changes that could influence the patient’s evolution. Our data was in agreement with the study carried out by Mjolstad, who advocated the introduction of this method as a tool for improving the diagnosis and treatment of abdominal and cardiac conditions [25].

The limitation of our study included its retrospective, nonrandomized design. Another limitation of this study was the fact that the US examination integrated in clinical examination was performed by an experienced emergency physician. From this point of view we do not know how our findings correspond to non-experts users. The stay in ED is mostly limited and a more realistic setting will probably be the US examination performed by residents. In spite of this, US examination may still be of significant value in case of critical patients which were excluded from our study. Another limitation of the study was the lack of verification of the negative US findings by other imaging techniques.

Conclusions

In conclusion the US as part of the clinical examination algorithm allowed the identification of non-critical pa-
patients who required emergency surgery, thus the immediate initiation of a different course of treatment was possible in 20.64% of patients. Regardless of the physician training, clinical diagnosis alone is insufficient, whereas nonspecific clinical symptoms lead to diagnostic errors, which are frequently detected late or during autopsy. The integration of point-of-care ultrasonography into the clinical examination enables better patient flow management in the emergency department by allowing the prioritization of decisions: patients requiring admission for medical and surgical treatment; patients who will undergo further diagnostic investigations; patients that can be referred to a family physician or outpatient care. The accidental identification of other morphological and pathological changes (28.31%) is crucial for the prevention, the monitoring and the evolution of patients, thus avoiding complications and further costs.

Conflict of interest: none

References