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Red Code Management in Pediatric Emergency Department: A Retrospective Study

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Abstract: The "red code" (RD) represents the highest levels of emergency in the emergency department (ED). The study retrospectively analyzed RDs in the Regina Margherita Children's Hospital ED, a regional referral center in north Italy, between 1 July 2020 and 30 June 2023. The aim was to describe RD characteristics and to identify significant correlations between presenting complaints and clinical management. The study includes 934 RDs (0.9% of overall ED admissions); 64% were assigned based on the Pediatric Assessment Triangle alteration. Most patients, 86.5%, followed the medical pathway, while 13.5% were surgical cases. Admission complaints were respiratory (46.9%), neuropsychiatric (26.7%), traumatic (11.8%), cardiologic (9.3%), metabolic (3.8%), and surgical (1.5%). Seventy-six per cent of patients received vascular access, and intraosseous access was obtained in 2.2% of them. In one-third of RDs, an urgent critical care evaluation was necessary, and 19% of cases required admission to the intensive care unit. The overall mortality rate was 3.4% (0.4% in ED setting). The study identified six distinct diagnostic pathways, each associated with specific characteristics in clinical presentation, management, therapeutic interventions, and outcomes: this underscored the significance of a systematic approach in improving outcomes in pediatric RD management.

Keywords: red code; emergency department; diagnostic pathways

1. Introduction

In the emergency department (ED) an adequate triage system is needed to ensure that children with severe condition can be immediately identified and quickly directed toward appropriate care [1–3]. The red code (RD) represents the highest urgency and requires immediate medical assessment [4]. In the international literature, there is a scarcity of epidemiological studies related to RDs ED admissions in the pediatric age group [4–6]. The goal of this study was to describe retrospectively epidemiological characteristics, admission features, clinical management, and outcome of RDs in a tertiary urban teaching Children's Hospital.

1.1. Background

1.1.1. Triage

In recent years a five levels triage system has been introduced in pediatric ED, identified by a color (white, green, light blue, orange, red) corresponding to an increasing degree of urgency [7]. The RD is defined as the absence or compromission of one or more vital functions and represents the priority access to medical evaluation; it constitutes a minority among pediatric ED admissions, representing 0.25-1% of total admissions according to local statistics [4,8]. The triage code assignment derives from evaluation of main complaint, vital signs and "quick look", a rapid assessment that does not require equipment but only quickly visual and auditory evaluations to assess its three

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components: appearance of the patient, respiratory function, and skin circulation, reflecting brain function, oxygenation, ventilation, and perfusion of the child [1].

1.1.2. RDs Management

The routine clinical management of RDs is based on Pediatric Advanced Life Support (PALS) approach, a systematic method to manage children in critical condition [9]. Alongside PALS algorithm, international guidelines and local hospital protocols aim to standardize care and optimize outcomes [10–13]. Diagnostic assessments to detect and identify severe clinical condition include bedside, laboratory and instrumental tests [9,14].

In our ED point-of-care (POC) blood tests are available, including blood count with c-reactive protein and multiparametric blood gas (including glucose, hemoglobin, creatinine, potassium, sodium, calcium ionized and chloride), useful to direct bedside clinical management. In recent years increasing importance has been given to POC ultrasound (US), closely related to operator's experience, but extremely useful in emergency setting as a rapid, reproducible, portable, and non-invasive method. The main scenery of its application is polytrauma by e-FAST protocol [15].

2. Materials and Methods

We retrospectively analyzed the patients admitted as RDs to the Regina Margherita Children's Hospital ED, a regional referral center in North-Western Italy, between 1 July 2020 and 30 June 2023.

2.1. Emergency Department Organization

The age range for ED admission is 0-14 years, extended to 18 years for children with chronic diseases followed-up at the hospital. Triage is managed by trained nurses. It was based on four levels system (white, green, yellow, red) until February 2022, when the five colors one was introduced. RD represents the priority access to medical evaluation for both systems. In our ED there is a distinction in "medical" and "surgical" patients, with separate pathways, waiting times and healthcare staff. Our ED has a related ward of short observation unit, lasting up to 36 hours. The hospital is provided of a pediatric intensive care unit (PICU) managed by anesthesiologic team.

2.2. Data Collection

We collected data about epidemiology, ED admission characteristics, initial management, blood and instrumental tests, initial therapeutic approach and outcome (short observation unit, pediatric ward or PICU admission, death) of the study population by computerized medical records of the hospital system.

We classified RDs admissions into six specific complaint categories: respiratory, cardiologic, metabolic, neuropsychiatric, surgical and traumatic.

2.3. Definition of Pathologic Items

Table 1 shows the criteria we used to define pathologic items.

Table 1. Criteria to define pathologic items.

Item	Criteria for pathologic definition
Systolic blood pressure	< 70 mmHg if age < 1 year OR < 70 + (2 x age in years) if age > 1 year OR > the 90th percentile for age, gender, and height
Multiparametric blood gas analysis	pH < 7.35 or > 7.45 OR blood glucose < 60 mg/dl or > 200 mg/dl

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	OR hemoglobin < anemia cutoff according to age OR serum sodium < 135 mmol/l or > 145 mmol/l
Blood count	white blood cells < 5000/mm3 or > 15000/mm3 OR platelets < 150000/mm3 OR hemoglobin < anemia cutoff according to age

2.4. Statistical Analysis

The statistical analysis was performed using IBM SPSS Statistics 27.0 (IBM Corp. Armonk, NY, USA). Significance was set at $p < 0.05$. All p-values were 2 tailed. In the descriptive analysis, categorical variables are reported as absolute numbers and percentages, and continuous variables as mean, median and interquartile range (IQR), as appropriate. To compare the continuous variables of the study groups, a Student's t-test was used. To evaluate the discrete variables, Pearson χ^2 and correlation Fisher exact tests were performed, as appropriate.

3. Results

3.1. Population Study

A total of 934 patients triaged as RDs were admitted to our ED between 1 July 2020 and 30 June 2023, equal to 0.9% of 105.798 total ED admissions in the period of the analysis. The 55.9% were male and the median age was 3.2 years. The medical pathway was the prevalent (808 patients, 86.5%), while surgical pathway consisted of 126 patients (13.5%). The different sex distribution between medical and surgical patients was statistically significant, with 54.2% of males in the medical group and 66.7% in the surgical one. Comorbidities were detected in 344 medical patients (42.6%) and in 11 surgical ones (8.7%), with a significant difference between the two groups. The 50% of the medical patients (404) arrived at the ED independently, while 65.1% of the surgical patients (82) were transported by ambulance ($p < 0.05$). The main complaints in order of frequency were: respiratory (438 patients, 46.9%), neuropsychiatric (249 patients, 26.7%), traumatic (110 patients, 11.8%), cardiologic (87 patients, 9.3%), metabolic (36 patients, 3.8%), and surgical (14 patients, 1.5%). The majority of the patients (64%) were triaged as RD due to PAT alteration, that was the main finding for RD definition in 100% of surgical patients. Table 2 shows the general descriptive characteristics of total study population and according to the medical and surgical pathway.

Table 2. General descriptive characteristics of total study population and according to the medical and surgical pathway. Statistically significant differences (p-value < 0.05) between medical and surgical population are highlighted in bold fonts.

Variable	Total	Medical	Surgical
Sex, n (%)			
Male	522 (55.9%)	**438 (54.2%)**	**84 (66.7%)**
Female	412 (44.1%)	**370 (45.8%)**	**42 (33.3%)**
Age, median (percentile25-percentile75) years	3.2 (1.1-7.4)	2.7 (0.9-6.8)	6.6 (2.7-11.3)
Access mode to ED, n (%)			
Independently	414 (44.3%)	**404 (50%)**	**10 (7.9%)**
Ambulance	276 (29.6%)	**194 (24%)**	**82 (65.1%)**
Transfer from another hospital	189 (20.2%)	**157 (19.4%)**	**32 (25.4%)**
Not reported	55 (5.9%)	53 (6.6%)	2 (1.6%)
Main finding for red code definition, n (%)			

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PAT	598 (64%)	**472 (58.4%)**	**126 (100%)**
SatO2	301 (32.2%)	**301 (37.2%)**	**0 (0%)**
HR	23 (2.5%)	**23 (2.8%)**	**0 (0%)**
RR	12 (1.3%)	**12 (1.6%)**	**0 (0%)**
Comorbidities, n (%)			
Yes	355 (38%)	**344 (42.6%)**	**11 (8.7%)**
No	577 (61.8%)	**463 (57.3%)**	**114 (90.5%)**
Not reported	2 (0.2%)	1 (0.1%)	1 (0.8%)

3.2. ED Admission Vital Signs

Among ED admission vital signs, level of consciousness, modality of breathing, body temperature, and skin description were registered in most the majority of patients, both medical and surgical. Blood pressure and capillary refill time were detected in a minority of cases. In detail, AVPU score and breathing description were reported in all 808 medical patients (100%) and in 125 surgical ones (99.2%); skin was descripted in 765 medical patients (94.7%) and in 106 surgical ones (84.1%); blood pressure was measured in 135 medical patients (16%) and in 66 surgical patients (52.4%), with pathologic values in respectively 3.2% and 10.3% of cases; capillary refill time was reported in 284 medical patients (35.1%) and in 13 surgical ones (10.3%), with pathologic detection in respectively 7.4% and 3.2% of cases. The difference found in vital signs at ED admission between medical and surgical patients was statistically significant for all parameters analyzed. Table 3 shows vital signs at ED admission of study population and according to the medical and surgical pathway.

Table 3. Vital signs at ED admission of study population and according to the medical and surgical pathway. Statistically significant differences (p-value < 0.05) between medical and surgical population are highlighted in bold fonts.

Variable	Total	Medical	Surgical
AVPU, n (%)			
A	598 (64%)	**538 (66.7%)**	**60 (47.6%)**
V	63 (6.8%)	**52 (6.4%)**	**11 (8.7%)**
P	119 (12.7%)	**103 (12.7%)**	**16 (12.7%)**
U	153 (16.4%)	**115 (14.2%)**	**38 (30.2%)**
Not reported	1 (0.1%)	0 (0%)	1 (0.8%)
Skin, n (%)			
Normal	598 (64%)	**578 (71.5%)**	**20 (15.9%)**
Pathologic	273 (29.2%)	**187 (23.2%)**	**86 (68.2%)**
Not reported	63 (6.8%)	43 (5.3%)	20 (15.9%)
Breathing, n (%)			
Spontaneous	718 (76.9%)	**633 (78.3%)**	**85 (67.5%)**
Oxygen support	159 (17%)	**152 (18.8%)**	**7 (5.5%)**
Intubation	56 (6%)	**23 (2.9%)**	**33 (26.2%)**
Not reported	1 (0.1%)	0 (0%)	1 (0.8%)
Blood pressure, n (%)			
Normal	162 (17.3%)	**109 (13.5%)**	**53 (42.1%)**
Pathologic	39 (4.2%)	**26 (3.2%)**	**13 (10.3%)**
Not reported	733 (78.5%)	673 (83.3%)	60 (47.6%)
Capillary refill time, n (%)			
Normal	233 (24.9%)	**224 (27.7%)**	**9 (7.1%)**
Pathologic	64 (6.9%)	**60 (7.4%)**	**4 (3.2%)**
Not reported	637 (68.2%)	524 (64.9%)	113 (89.7%)

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3.3. Vascular Access

A vascular access was provided in 714 patients (76% of total study population), of which 600 were medical (84%) and 114 surgical (16%). This means that a venous access was provided in 74% of medical patients and in 90% of surgical ones. Instead, 202 medical patients (25.1%) and 5 surgical ones (4%) were managed without venous access in ED setting. The different use of vascular access in the two pathways was statistically significant.

The peripheral venous catheter (CVP) was the most used type of vascular access, placed in 707 patients (75.7% of total study population). CVC was provided in 1 patient (1.1%) and IO access in 21 patients (2.2%); in 15 patients (1.6%) were placed both CVP and IO. In detail, among 21 patients managed with IO access, the main complaint was cardiologic in 8 patients (38%), neuropsychiatric in 5 (24%), respiratory in 4 (19%), traumatic in 4 (19%); 12 of them (57%) were admitted to PICU and death occurred in 9 of them (43%). These last two frequencies were higher than those of total study population, as presented in the following paragraphs.

3.4. Emergency Tests

Blood count and multiparametric blood gas analysis were the main emergency tests performed. The use of these tests was different ($p<0.05$) between medical and surgical patients: blood count was performed in 554 medical patients (68.6% of medical group) and in 98 surgical patients (77.8% of surgical group), while multiparametric blood gas analysis was performed in 636 medical patients (78.7% of medical group) and in 73 surgical ones (57.9% of surgical group). A significant difference between medical and surgical pathway was also found in the performance of ECG and CT scan: ECG was performed in a selected part of patients (19% of total patients) and CT scan was mostly used in surgical RDs (10.1% of medical patients vs 64.3% of surgical ones). US was executed in about one third of patients (including both bedside and specialistic US), without significant difference between the two pathways. The anesthesiologist was involved in 54% of surgical RDs but only in one quarter (25.5%) of medical ones, with a significant difference between the two pathways. Table 4 shows the clinical management of medical and surgical population.

Table 4. Clinical management of medical and surgical population. Statistically significant differences (p-value < 0.05) between medical and surgical population are highlighted in bold fonts.

Management	Medical	Surgical
Vascular access, n (%)		
CVP	**582 (72.1%)**	**110 (87.3%)**
IO	**5 (0.6%)**	**1 (0.7%)**
CVC	**1 (0.1%)**	**0 (0%)**
IO + CVP	**12 (1.4%)**	**3 (2.4%)**
No access	**202 (25.1%)**	**5 (4%)**
Blood count, n (%)		
Not performed	**254 (31.4%)**	**28 (22.2%)**
Performed	**554 (68.6%)**	**98 (77.8%)**
Pathologic	190 (34%)	49 (50%)
Blood gas analysis, n (%)		
Not performed	**172 (21.3%)**	**53 (42.1%)**
Performed	**636 (78.7%)**	**73 (57.9%)**
Pathologic	309 (48.6%)	20 (27%)
Electrocardiogram, n (%)		
Not performed	**637 (78.8%)**	**119 (94.4%)**
Performed	**171 (21.2%)**	**7 (5.6%)**
Pathologic	28 (16.4%)	2 (28.6%)
Ultrasound, n (%)		
Not performed	553 (68.4%)	80 (63.5%)

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Performed	255 (31.6%)	46 (36.5%)
Pathologic	107 (42%)	13 (28.3%)
CT scan, n (%)		
Not performed	**726 (89.9%)**	**45 (35.7%)**
Performed	**82 (10.1%)**	**81 (64.3%)**
Pathologic	25 (30.5%)	55 (68%)
Anesthesiologic consultation, n (%)		
Yes	**206 (25.5%)**	**68 (54%)**
No	**602 (74.5%)**	**58 (46%)**

3.5. Therapeutic Approach

Table 5 shows a detailed breakdown of drugs' macro-categories administration in study population and according to the medical and surgical pathway.

Table 5. Therapeutic approach in total study population and according to the medical and surgical pathway. Statistically significant differences (p-value < 0.05) between drugs administration in medical and surgical population are highlighted in bold fonts.

Therapeutic approach	Total	Medical	Surgical
Oxygen or ventilation, n (%)	548 (58.7%)	**521 (64.5%)**	**27 (21.4%)**
Crystalloids, n (%)	106 (11.3%)	**79 (9.8%)**	**27 (21.4%)**
Colloids, n (%)	28 (3%)	**20 (2.5%)**	**8 (6.3%)**
Glucagon or insulin, n (%)	26 (2.8%)	25 (3.1%)	1 (0.8%)
Electric therapy, n (%)	0 (0%)	0 (0%)	0 (0%)
Anticonvulsants, n (%)	98 (10.5%)	**96 (11.9%)**	**2 (1.6%)**
Sedatives, n (%)	47 (5%)	**26 (3.2%)**	**21 (16.7%)**
Psychoactive drugs, n (%)	11 (1.2%)	11 (1.4%)	0 (0%)
Antibiotics or antivirals, n (%)	172 (18.4%)	155 (19.2%)	17 (13.5%)
Antipyretics or analgesics, n (%)	269 (28.8%)	233 (28.8%)	36 (28.6%)
Antiemetics, n (%)	23 (2.5%)	17 (2.1%)	6 (4.8%)
Steroids, n (%)	260 (27.8%)	**257 (31.8%)**	**3 (2.4%)**
Drugs acting or airways, n (%)	376 (40.2%)	**376 (46.5%)**	**0 (0%)**
Diuretics, n (%)	12 (1.3%)	12 (1.5%)	0 (0%)
Cardioactive drugs, n (%)	27 (2.9%)	23 (2.8%)	4 (3.2%)
Dressings, n (%)	24 (2.6%)	**1 (0.1%)**	**23 (18.3%)**

In detail, 548 total patients (58.7%) were supported by oxygen or ventilation: 521 of them belonged to the medical pathway (equal to 64.5% of this group) and 27 to the surgical one (equal to 21.4% of this group), with a significant difference between the two pathways. A significant difference was also found for drugs acting on airways, that were used in 40.2% of total patients, represented exclusively by medical patients. Antibiotics or antivirals were administered to 18.4% of patients (without significant difference between the two pathways), while steroids, antipyretics, and analgesic to about one third of the study population. Diuretics and psychoactive drugs were exclusively used in medical patients, respectively in 1.5% and 1.4% of them. Dressings were realized in 2.6% of total patients and they were mainly used in surgical patient (18.3% of this patients' group, with a significant difference compared to the medical group). Electric therapy has never been used.

3.6. Mortality Rate

The mortality rate of RDs in ED setting was 0.4% (4 medical patients). The overall mortality rate was 3.4% (32 patients of total study population), presenting in 2.8% of medical patients (23 patients) and in 7.1% of surgical ones (9 patients), with a statistically significant difference between the two pathways. While 12.5% of total deaths occurred in ED, PICU was the setting where death mainly

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occurred (24 patients, equal to 75% of deaths) and the remaining 12.5% (4 patients) died in hospital wards.

3.7. Hospital Admission

A total of 68 patients (7%) were directly discharged from ED. Instead, about hospital admission after ED management, 175 patients (18.7%) were admitted to PICU, 274 (29.3%) to short observation unit, and 410 (44%) directly to hospital wards. PICU admission has been the choice for 120 medical patients (14.9%) and for 55 surgical ones (43.7%), with a significant difference between the two pathways. A significant difference between the two pathways was also found in the admission to short observation unit, chosen for 269 medical patients (33.3%) and only for 5 surgical ones (4%). In the overall management of hospital admissions, 702 patients (75.2%) were admitted to hospital wards or directly from ED, or following PICU, or after short observation unit. Table 6 shows the hospital admission modality of total study population and according to the medical and surgical pathway.

Table 6. Hospital admission modality of total study population and according to the medical and surgical pathway. Statistically significant differences (p-value < 0.05) between medical and surgical population are highlighted in bold fonts.

Admission modality	Total	Medical	Surgical
Pediatric intensive care unit, n (%)			
No	759 (81.3%)	**688 (85.1%)**	**71 (56.3%)**
Yes	175 (18.7%)	**120 (14.9%)**	**55 (43.7%)**
Short observation unit, n (%)			
No	660 (70.7%)	**539 (66.7%)**	**121 (96%)**
Yes	274 (29.3%)	**269 (33.3%)**	**5 (4%)**
Hospital ward, n (%)			
No	232 (24.8%)	**216 (26.7%)**	**16 (12.7%)**
Yes	702 (75.2%)	**592 (73.3%)**	**110 (87.3%)**

The six main complaints were characterized by different duration of hospital admission, calculated from ED triage until final discharge, including recovery in short observation unit, PICU, and hospital ward. The mean duration of hospitalization is illustrated in table 7.

Table 7. Mean duration of hospitalization according to main complaint.

Main complaint	Mean duration of hospitalization, days (SD)
Respiratory	12 (± 17)
Neuropsychiatric	11 (± 16)
Traumatic	14 (± 17)
Cardiologic	10 (± 14)
Metabolic	7 (± 4)
Surgical	18 (± 17)

3.8. Diagnostic Pathways

In our study population we identified six clearly different diagnostic pathways, each one defined by specific characteristics in term of admission parameters, clinical management, therapeutic approach, and outcome: respiratory, neuropsychiatric, traumatic, cardiologic, metabolic, and surgical. The cardiologic category included not only cardiac arrhythmias but also circulatory disturbance with all types of shock; the metabolic group primarily consisted of glycemic abnormalities, both severe hypoglycemia (for example in children with congenital metabolic diseases) and ketoacidosis at the onset of type 1 diabetes; the smallest pathway (1.5%) consisted of true surgical patients, represented by cases of acute abdomen or neurosurgical emergencies.

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Regarding RD definition, 100% of metabolic, neuropsychiatric, and traumatic patients were triaged as RDs for PAT alterations, while 69% of respiratory patients for desaturation at admission. Comorbidities were associated with neuropsychiatric complaints in 50% of cases (including both neurologic diseases and psychiatric disturbs) and they were absent in 93% of traumatic RDs. Among admission vital signs, 86% of respiratory patients were alert, 24% supported by oxygen and 74% with normal skin; in contrast, among traumatic RDs, 31% were unresponsive, 28% intubated and 72% with pathologic skin; AVPU was pathologic (P or U) in 59% of neuropsychiatric patients; altered skin was found in cardiologic patients (paleness, cyanosis, marbling) and surgical ones (burn, ecchymosis, wound, abrasion). About clinical management, blood count was performed in 84% of traumatic RDs; multiparametric blood gas analyses in 78% of respiratory and in 97% of metabolic ones; ECG in 26% of neuropsychiatric, 58% of metabolic, and 52% of cardiologic patients. 53% of traumatic RDs requested anesthesiologic consultation and 43% PICU admission, both rare in respiratory emergencies (respectively 23% and 15%). Deaths were statistically significantly associated with cardiac complaints (13% of these patients) and traumatic complaints (7%), while mortality rate among respiratory patients was lower than statistically expected (1.5%). Table 8 represents in detail the statistically significant correlations between diagnostic pathways and ED management items.

Table 8. Statistically significant correlations between diagnostic pathways and ED management items.

Diagnostic pathway	Correlations with p-value < 0.05
Respiratory (438 patients, 46.9%)	Red code for SatO2 At ED admission: • AVPU: A • B: oxygen • Normal skin Clinical management: • Vascular access: less than expected • EGA: more than expected • Blood count: less than expected • Anesthesiologic consultation: less than expected Therapeutic approach: • Oxygen • Steroids • Drugs acting on airways • Antibiotics and antivirals Admission modality: • PICU: less than expected • Short observation unit: more than expected Deaths: less than expected
Neuropsychiatric (249 patients, 26.7%)	Red code for PAT alteration Comorbidities At ED admission: • AVPU: P or U Clinical management: • ECG: more than expected Therapeutic approach: • Anticonvulsants • Psychoactive drugs • Antiemetics
Traumatic (110 patients, 11.8%)	Transported by ambulance No comorbidities Red code for PAT alteration

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	At ED admission: • AVPU: U • B: intubated • Pathologic skin Clinical management: • Blood count: more than expected • Anesthesiologic consultation: more than expected Therapeutic approach: • Crystalloids • Colloids • Sedatives • Dressings Admission modality: • PICU: more than expected Deaths: more than expected
Cardiologic (87 patients, 9.3%)	At ED admission: • Pathologic skin Clinical management: • ECG: more than expected Therapeutic approach: • Crystalloids • Colloids • Cardioactive drugs Deaths: more than expected
Metabolic (36 patients, 3.8%)	Red code for PAT alteration Clinical management: • EGA: more than expected • ECG: more than expected Therapeutic approach: • Crystalloids • Glucagon • Insulin
Surgical (14 patients, 1.5%)	At ED admission: • Pathologic skin Clinical management: • Blood count: more than expected Therapeutic approach: • Dressings

4. Discussion

International literature is lacking in epidemiological studies related to RDs in pediatrics and these studies are often characterized by very different socio-cultural and environmental contexts.

The RDs constituted a minority of our ED admissions, representing less than 1% of total admissions; this low incidence is in line with local statistics and with data of similar studies conducted at the Children's Hospital ED of Padua (1.276 RDs in 5 years) and at the Children's Hospital ED of Trieste (251 RDs in 4 years) [4,6,8].

Medical pathway was the prevalent path and was characterized by a frequent presence of comorbidities related to the main complaint. This might be justified by the fact that our ED is part of a tertiary Children's Hospital, where patients are followed for their underlying chronic condition but where they also seek care for acute issues. In our analysis the respiratory problems were the most common ED admission complaint and they were typically represented by respiratory failure

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primarily due to bronchitis, pneumonia, bronchiolitis or acute asthma attack in most cases. Regarding access mode to ED, most of surgical patients were taken by ambulance, including both advanced transport with helicopter rescue and territorial rescue system, used in particular for victims of accidents, in accordance with international literature [16].

RDs require a prompt recognition to ensure their adequate management and to improve their outcome [1–3]. According to the international literature, an efficient triage system is needed to a correct priority code assignment: alongside vital signs, nurses' experience is crucial to catch PAT alterations, that in our study were the main motive of RD definition [1,3,17]. The assessment of vital signs plays a crucial role non only in triage code assignment but also in the management according to the PALS protocols, with the goal of a fast recognition of respiratory distress, respiratory failure, and shock to immediately take life-saving interventions [3,9,18]. We detected significantly different vital signs at ED admission between medical and surgical patients: this last group, having more compromised breathing and consciousness, more frequently required the intervention of the anesthesiologist. Blood pressure and capillary refill time were reported in a minority of cases, but these two parameters should be remembered as part of the primary assessment of critical patients for assessing peripheral perfusion [9].

Obtaining venous access in critically ill children is an essential procedure to restore blood volume and administer drugs during pediatric emergencies. The first option for vascular access is through a peripheral vein puncture, but if this cannot be used or if takes too long time to be placed, the intraosseous route is an effective option for rapid and safe venous access [9,19]. In our analysis, vascular access was established in most patients: as expected, CVP was the most used type, while IO access was obtained in 2.2% of total population. International literature reports a rare use of intraosseous access in pediatric age, typically in extremely instable and critical patients; however, the incidence varies significantly from one study to another (from 0.02% to 20%), according to the study population analyzed [5,20–22]. In our setting, typical clinical condition managed with IO access were polytrauma, status epilepticus, severe respiratory insufficiency, and cardiocirculatory instability, all characterized by an extremely severe clinical picture: this also justifies the high rate of PICU admissions and deaths found among this category of patients.

In ED setting clinicians need to make accurate and timely decisions regarding emergency management and POC tests have the potential to provide rapid and accurate results [9,14]. In our analysis, blood count and multiparametric blood gas analysis were largely performed and they provided a great part of pathologic results, confirming the utility of their execution. ECG was significantly correlated not only with cardiologic complaint, but also with metabolic and neuropsychiatric problems, in which it was necessary respectively for finding anomalies induced by electrolyte disturbances and for calculating corrected QT interval.

In recent years, we have assisted to a widespread adoption of bedside US in pediatric ED; international literature has emphasized its usefulness in the pediatric emergency setting, representing a non-invasive and rapidly performed technique, performable even on unstable patients during resuscitative maneuvers and useful not only in the diagnostic process but also in the primary assessment [9,15,23]. Unexpectedly, in our study ultrasound was performed in only one third of the patients, considering both bedside and specialistic exams: this could be in part attributed to the limited use of e-FAST US in polytrauma, that was more commonly managed through the execution of CT scan, which provided pathological findings in a great portion of cases. The most frequently used US was the pleuropulmonary one, but we should implement the use of US as a component of the patient's primary assessment, especially in cases of hemodynamic instability, as it allows for a rapid evaluation of cardiac function and volume status, in accordance with ongoing international literature [3,24–26].

Drugs used in ED therapeutic approach can be divided in macro-categories [6] and we found some significative correlations between their administration in medical and surgical pathway, exception for antibiotics, antiviral, antipyretics and analgesic, that were used across different types of patients without specificity to any diagnostic pathway. Antiemetics, diuretics, psychoactive, and cardioactive drugs have been rarely used, and this may have affected their lack of statistical

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significance. Electric therapy, including both defibrillation and cardioversion, was never utilized and this reinforces the possibility that pediatric emergency medicine faculty are at significant risk for skill deterioration, especially concerning critical procedures performed in pediatric ED [22]. Statistically significant correlation were also found between the administration of some drugs and admission main complaint: for example, oxygen, steroids, drugs acting on airways (mainly bronchodilator via aerosol or intravenous administration), and antibiotics in respiratory patients; antiemetics, anticonvulsants and psychoactive drugs (antipsychotics and benzodiazepines) in neuropsychiatric patients; crystalloids, colloids, sedatives, and dressings in traumatic patients; colloids, crystalloids and cardioactive drugs (adenosine, adrenaline, atropine, beta-blockers) in cardiologic patients; crystalloids, glucagon, and insulin in metabolic patients; dressings in surgical patients, all in accordance with the guidelines and the hospital protocols [9,11–13,27,28].

As supported by literature, close working relationships between ED and PICU is fundamental to ensure better outcome [29,30]. Pediatric settings are characterized by pediatrician as the frontline figure in facing emergencies, tasked with managing various consultants, including the anesthesiologist, unlike in the adult world where RDs are often handled by specialists. In our setting, a low percentage of RDs was admitted to PICU. The anesthesiologist was largely involved in surgical RDs because they were often admitted intubated (so requiring advanced airway management) or in critical condition requiring rapid management in operating room. For these same reasons, approximately half of them was admitted to PICU. Among surgical patients, the main part was represented by traumatic complaints, including polytrauma and burns: their critical condition justifies a higher PICU admission and a higher mortality rate than expected, with statistical significance. As mentioned earlier, PICU admission had also a statistically significant correlation with patients managed with intraosseous access.

Regarding hospital admission modality, we usually reserved short observation unit to RDs with a prognosis of rapid resolution (for example febrile seizure or acute asthma attack), in accordance with literature [31]. In our setting, we have also detected that during the epidemic season short observation unit served as a temporary arrangement while awaiting admission to regular inpatient ward. The duration of hospitalization was extremely variable according to main complaint, ranging from respiratory patients discharged directly from ED to psychiatric patients hospitalized for months.

The mortality rate of RDs in our ED setting was 0.4% and the overall mortality rate was 3.4%: this might attested to the appropriate teamwork management of RDs in our ED. As expected, overall mortality is lower compared to resource-limited countries, but surprisingly higher compared to Children's Hospital of Padua (0.7%) [4,5,32,33]. This can be the consequence of a different organization of regional networks of trauma centers, but also of the fact that Regina Margherita Children's Hospital is a reference center for rare and complex conditions such as metabolic, neurosurgical, and cardiovascular diseases. As mentioned earlier, we found a higher mortality rate in patients managed with intraosseous access, but also in patients with traumatic and cardiac complaints, representing the most critical patients' categories. Regarding the setting where deaths occurred, in our study only 4 patients died in ED, while PICU was the setting where death mainly occurred, partially related to underlying incurable comorbidities. Despite death being a rare event in the ED setting, its management underscores the importance of not only medical expertise but also of the ability to provide compassionate and empathetic care during an incredibly distressing time, providing emotional support and comfort to the grieving family and ensuring adequate debriefing for the entire teamwork [34].

The RDs represent a wide heterogeneous category of patients united by critical condition, but we identified six clearly defined diagnostic pathways. This reinforced the concept that RDs management should be based on a systematic approach, driven not only by the application of international protocols but also by a clear categorization of patients upon ED admission, allowing for specific management pathways and tailoring care. Regarding the respiratory pathway, that was the most common, a higher proportion than expected was managed without vascular access and without anesthesiologic consultation, while deaths and PICU admissions were lower than predicted; a greater

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use was reserved for short observation unit, often sufficient to solve the acuteness. These data might attest to the confidence of our ED team in managing respiratory RDs, supported by clinical experience and clear protocols [27,28]. On the contrary, our ED was just a transitional point for a great part of surgical and traumatic patients, as they were directly managed in PICU or specialized wards.

A systematic clinical approach supported by defined diagnostic pathway enables action in the emergency setting according to standardized and defined protocols, reducing the risk of errors and improving outcomes. Clearly defined diagnostic pathways could be a useful support also for first level pediatric ED, where the daily number of admissions is significantly lower than our setting; therefore, RDs represent a sporadic occurrence but still require a prompt and effective management.

Strengths of our analysis included the large size of study population and the setting in which it was conducted: being a tertiary hospital, it was adequate for managing high-complexity codes. Among the study's limits, there was a percentage of "not reported" data, either because they were not detected or simply not recorded in the clinical records. Since this was a retrospective study, it would be suitable to expand it with a prospective study for a more comprehensive evaluation.

5. Conclusions

In the RDs management pediatricians can be helped by a systematic approach, supported by international and national guidelines, but also by clearly defined diagnostic pathways.

Respiratory patients' management represents a daily clinical challenge in the heterogeneity of pediatric emergencies.

The use of beside ultrasound during critical scenarios should be implemented in the ED setting because it is quickly available, non-invasive, and performable even on unstable patients during resuscitative maneuvers, providing early diagnostic insights useful to complete primary assessment.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author due to ongoing study.

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