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The Ross classification as a tool for nursing evaluation in pediatric patient with heart disease.

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ABSTRACT

Background

Heart failure is a clinical syndrome following myocardial dysfunction with inadequate response to the body's metabolic demands. It appears more critical and complex in children than in adults. It is essential to treat this condition early: for this reason, the Ross classification was developed, which assigns a score to the patient based on the presented signs and symptoms.

Aims

The primary aim was to evaluate whether the data (signs, symptoms and behaviors of the child) collected non-invasively by the nurse were predictive of the risk of heart failure according to the Ross Classification in a cohort of pediatric patients after cardiac surgery for correction of atrial septal defect (ASD) or ventricular septal defect (VSD). The secondary aim was to correlate the trend of the scores obtained from the classification with variables such as hospitalization time (in days) and number of rehospitalizations.

Methods

Retrospective observational study conducted on a sample of medical and nursing records of patients between 0 and 18 years hospitalized at the Congenital Pediatric Cardiology and Heart Surgery - Pediatric Intensive Care Unit of Azienda Ospedaliero Universitaria delle Marche in 2021. A score was assigned according to the Ross Classification to each patient. A statistical analysis followed using Wizard and STATA software.

Results

Most of the patients belonged to the second class of Ross (51%), while none presented parameters included in the fourth class. It emerged that patients included in the second and third classes of Ross had a longer hospital stay than those who were included in the first class as well as a greater relative risk of total hospital stay. Hospitalizations involved 5% of the sample (3/57).

Conclusions

Nurse is fundamental in the detection of the parameters for the computation of the Ross classification in heart failure in pediatrics. In addition to the clinical-instrumental data, observation during feeding and the severity of the related respiratory distress is fundamental.

The creation of a multidisciplinary team that addresses every aspect related to heart failure allows an effective comparison between different health professionals and an excellent level of assistance.

Keywords

heart failure, Ross Classification, pediatric cardiac patient, nursing.

INTRODUCTION

Heart failure is a clinical syndrome characterized by a dysfunction of the myocardium, no longer able to satisfy the metabolic needs of the body.

The causes can also vary based on the age of the subject: in adults it often results from coronary heart disease or hypertension; in pediatric patients it follows simple or complex heart diseases, such as atrial septal defect (ASD), ventricular septal defect (VSD) and aortic coarctation [1][2].

These last three diagnoses necessarily require surgical treatment, if hemodynamically significant. The management of the post-operative path of a child suffering from heart failure is essential to guarantee a favorable clinical course and avoid a worsening of their condition.

Nowadays, a key point is that, thanks to innovative medical and surgical therapies, an ever-increasing number of children with heart failure are able to reach adulthood: treating a person early allows for a long-term improvement in their life [3][4].

In recent decades, there has been an increasing focus on finding prevention strategies for the complications of pediatric or neonatal heart disease, also considering how difficult it is to recognize the variety of signs and symptoms potentially present at such an early age [5].

Until 1987, the only system available for classifying heart failure in pediatric patients was the New York Heart Association (NYHA) Classification. However, this system was based on physical activity limitations for adults, which did not translate well for use in children, especially infants. Therefore, a classification was developed based on the most age-appropriate symptoms.

In this regard, Robert Ross, a physician specialized in pediatric cardiology at the Children's Hospital in Michigan, designed a scale including various parameters [6] and modified over the years, as numerous relationships have emerged among these, values of blood chemistry tests and characteristics specific to each patient: the Ross Classification [7].

The nursing role involves a considerable responsibility that should not be taken for granted during care, such as that of preventing infections, particularly in the post-operative period where the patient is more susceptible to this complications, with a view to reducing hospitalization times and improving outcomes [8].

Even in cardiac surgery, the figure of the nurse is crucial since it is precisely this professional who reconciles the clinical eye with the clinical-instrumental parameters detected at regular intervals thanks to continuous care to patients.

The detection of signs, symptoms and behaviors of the child during feeding, breathing and even sleeping could support instrumental, often invasive medical diagnostics (such as trans-esophageal echocardiography with color doppler, blood sampling for blood chemistry tests), and could help to accurately and non-invasively predict the risk of heart failure for each age group.

AIMS

The main objective of the study was to evaluate whether the data (signs, symptoms and behaviors of the child) collected non-invasively by the nurse were predictive of the risk of heart failure according to the Ross Classification in a cohort of pediatric patients after cardiac surgery to correct ASD or VSD. The secondary objective was to correlate the trend of the scores obtained from the classification with variables such as length of stay (in days) and number of re-hospitalizations.

MATERIALS AND METHODS

Study design

A retrospective observational study was conducted in the period between February and September 2021 in the Pediatric and Congenital Cardiology and Cardiac Surgery department - Pediatric Intensive Care Unit (ICU) of the Azienda Ospedaliero Universitaria delle Marche, with sampling upon patient entry into the department, 24 hours after cardiac surgery, at discharge and at one year (follow-up of the same patients).

Sample

57 integrated medical records of 57 patients between 0 and 18 years old, with a median age of 4 ±2 years, of which 47% were female, were evaluated. All patients were admitted to the ICU to undergo elective cardiac surgery for the correction of an ASD or VSD. Inclusion criteria were: having undergone cardiac surgery for ASD or VSD correction and being <18 years old. Conversely, exclusion criteria were: the unavailability of data in the integrated medical record useful for calculating the Ross Class during hospitalization and the unavailability of follow-up data.

Study setting

The Pediatric and Congenital Cardiology and Cardiac Surgery Department – Pediatric Intensive Care Unit of the Azienda Ospedaliero Universitaria delle Marche.

Data collection methodology and survey tools

The data collection took into consideration the whole period of hospitalization of the patient and occurred through direct consultation of the medical records.

At first, the organization of the collected material took place on an Excel table including the following items: age, sex, weight, diagnosis, type and date of the operation, Extra Corporeal Circulation (CEC) with duration, clamping time and temperature, redo-surgery (redo), origin, date of discharge, values of blood tests and Ross parameters (nutrition, breathing, heart and

respiratory rates, saturation, hepatomegaly, ejection fraction, degree of atrio-ventricular insufficiency) at admission, 24 hours after surgery and at discharge; therapy taken, length of stay in the Post-Operative Intensive Care Unit (PO-ICU), length of overall stay and number of subsequent hospitalizations, for a follow-up period of one year from discharge.

For the purposes of the study, the final sample was divided and analyzed according to Ross' Functional Class. The recruited population was divided into categories based on age and, in line with the different ranges of parameters belonging to each category, a score was assigned to each of the patients taken into consideration according to the Ross Functional Class. For some variables such as type B Natriuretic Peptide (BNP) and hepatomegaly, standard values were adopted: for BNP reference was made to the first class with results <100 pg/ml; to the second if the values were between 100 and 300 pg/ml; while, belonging to the third class, with values above 300 pg/ml. However, as regards hepatomegaly, based on the severity of the latter, the score was assigned to the patient considering the first class if mild, the second class if moderate, the third class if severe. With regard to all the other parameters included in the Ross Classification, we instead adhered to the specific ranges indicated in each category (7). The only parameter that was not included was the perfusion. The 4 Ross Functional Classes which the sample was classified with are explained below.

Ross Functional Class:

1) No limitations or symptoms

2) Mild dyspnea and growth restriction

3) Marked dyspnea, increased sucking time, growth arrest

4) Dyspnea at rest with rib indentations

The complete synopsis of the study with inclusion criteria and subsequent work plan is shown in Figure 1.

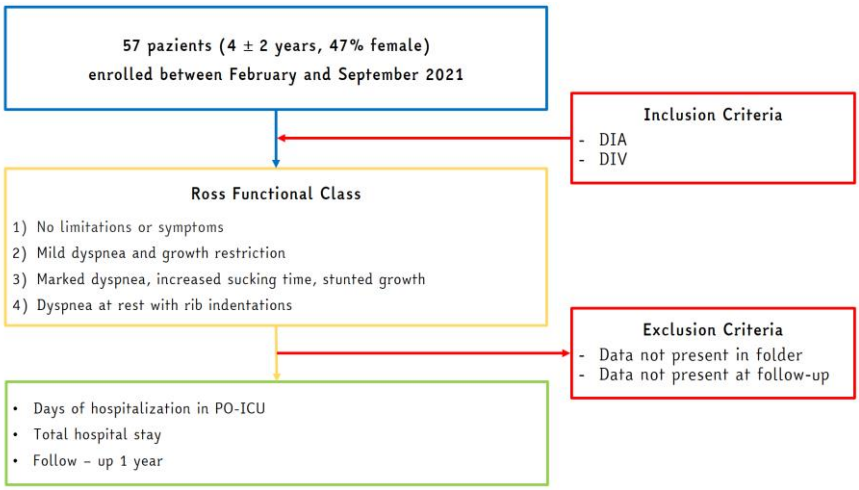

Figure 1: Synopsis and inclusion/exclusion criteria of the study (self-produced figure)

Statistical analysis

Categorical variables were expressed as absolute number and percentage, while continuous variables were expressed as mean ± standard deviation (SD) or median and 25th-75th percentile (Q1, Q3), as appropriate.

Differences between groups were analyzed using the chi-square test ($\chi 2$), in the case of categorical variables, while those between continuous variables were evaluated using a non-parametric test or with the t-test, where required by the sampling distribution.

Furthermore, for the purposes of statistical analysis, the sample was divided into four categories depending on the attributed Ross Class; subsequently, the differences found between the different classes were evaluated.

These differences were evaluated using a trend test (non-parametric test for ranks which analyzes the different characteristics of the same population when the objective is to evaluate the presence of an association between a variable with two categories and an ordinal variable with k categories, where k represents all the different possible categorizations of the same variable).

Kaplan-Meier curves were used to estimate the Survival Function, indicative of the duration of the hospitalization period and subsequent hospitalizations during follow-up. To compare, however, the differences between the survival curves belonging to the different Ross Classes, the Log-rank Test was used to evaluate their Failure Rate, i.e. the estimate of the frequency with which n-groups under examination undergo "failure" or "the event" under consideration.

Finally, a generalized linear model was created to evaluate independent predictors of prolonged hospitalization. All analyzes were adjusted for age, sex, and body weight.

The statistical analysis was conducted using dedicated software for statistical calculation such as Wizard, version 1.9.18 (233) and STATA, version 15 (Stata Corp., College Station, Texas).

Ethical aspects

Participation in the study was voluntary and each patient was guaranteed anonymity (with assignment of an ID code for each patient) and protection of privacy according to the European Regulation GDPR 679/2016.

The study was conducted according to the Declaration of Helsinki. Given the retrospective observational nature of the research, approval from the Ethics Committee was not necessary.

However, for the purpose of data collection, formal authorization was previously obtained from the Director of Pediatric and Congenital Cardiology and Cardiac Surgery Department – Pediatric Intensive Care Unit, the Hospital Medical Management Head and the Nursing Professions Head, and informed consent was given by the parent (and/or the patient, where possible).

RESULTS

General population

56% (n=32/57) of the enrolled patients underwent surgical correction of ASD, while 44% (n=25/57) of VSD. Regarding the enrolled population, 12% (n=7/57) were in Ross first class, 51% (n=29/57) in second class, while 37% (n=21/57) in third class. No enrolled patient was in fourth grade. The general characteristics, anthropometric, laboratory, clinical-instrumental data, therapy taken and follow-up are shown in Table 1 divided by functional class.

Table 1. General characteristics according to Ross functional class

	Ross 1 n=7	Ross 2 n=29	Ross 3 n=21	P-Value
Anthropometric data				
Age (years)	5 ± 4	4 ± 2	4 ± 3	0.79
Weight (Kg)	11.3 ± 10.1	13.6 ± 9.0	10.3 ± 8.3	0.46
Diagnosis (VSD)	3 (42.9 %)	11 (37.9 %)	11 (52.4 %)	0.46
Laboratory data				
Hemoglobin (g/dL)	12.5 ± 2.2	13.5 ± 1.8	12.4 ± 1.1	0.50
Hematocrit (%)	35.2 ± 6.2	38.7 ± 5.0	35.7 ± 2.8	0.81
MCV (mm)	85.5 ± 3.7	76.9 ± 5.1	78.1 ± 4.0	**0.032**
Leukocytes (x 10^3/mmc)	8.0 ± 2.0	10.0 ± 2.6	9.1 ± 2.0	**0.046**
Neutrophils (x 10^3/mmc)	2.9 ± 1.3	3.9 ± 2.6	4.8 ± 2.6	**0.001**
Lymphocytes (x 10^3/mmc)	3.6 ± 1.8	4.4 ± 2.1	4.0 ± 1.8	**0.017**
Monocytes (x 10^3/mmc)	0.9 ± 0.4	1.0 ± 0.6	0.8 ± 0.5	0.76
Basophils (x 10^3/mmc)	0.1 ± 0.01	0.2 ± 0.01	0.1 ± 0.01	0.99
Platelets (x 10^3/mmc)	355.4 ± 235.6	259.2 ± 137.4	292.1 ± 102.1	0.10
Creatinin (mg/dL)	0.3 ± 0.1	0.3 ± 0.0	0.3 ± 0.1	< **0.001**
Troponin (ng/dL)	10.0 ± 1.7	39.3 ± 77.6	60.9 ± 129.2	**0.003**
CRP (mg/dL)	1.1 ± 1.3	2.0 ± 3.4	3.2 ± 3.8	**0.005**
BNP (ng/dL)	61 (25, 89)	97 (65, 135)	131 (90, 233)	< **0.001**
Clinical-instrumental parameters				
Total feeding time (minutes)	20 ± 0.6	22 ± 0.6	30 ± 0.7	0.47
Respiratory distress (yes/no)	0 (0 %)	2 (6.8 %)	3 (14.3 %)	**0.042**
Feeding pauses (n°)	0 [0, 0]	1 [0, 1]	2 [1, 2]	**0.022**
RF (act/min)	55 ± 0.7	65 ± 0.7	70 ± 0.8	< **0.001**
HR (bpm)	102 ± 0.5	130 ± 0.9	150 ± 0.7	< **0.001**
SpO2 (%)	99 ± 0.01	99 ± 0.01	100 ± 0.1	0.99
Hepatomegaly (yes/no)	3 (42.8 %)	4 (13.7 %)	5 (23.8 %)	0.07
EF (%)	63 ± 0.6	55 ± 0.01	50 ± 0.3	**0.025**
MI mod-sev (yes/no)	0.7 ± 0.7	0.0 ± 0.0	5 (33.3 %)	**0.017**
Therapy				
Furosemide	5 (71 %)	15 (52 %)	15 (71 %)	0.99
Spironolactone	6 (85%)	6 (21 %)	15 (71 %)	**0.004**
Aspirin	0 (0%)	9 (31 %)	15 (71 %)	**0.001**
Captopril	0 (0%)	3 (10 %)	12 (57 %)	**0.001**
Propranolol	0 (0 %)	0 (0 %)	3 (14 %)	0.41
Carvedilol	0 (0 %)	3 (10 %)	12 (57 %)	**0.001**
Follow-up				
PO-ICU length of stay (days)	1.6 ± 1.2	2.0 ± 0.7	4.8 ± 1.7	**0.001**
Total length of stay (days)	9.8 ± 2.3	17.8 ± 8.3	23.6 ± 3.8	**0.001**
Number of subsequent hospitalizations (n°)	0 (0 %)	1 (3.4 %)	3 (9.5 %)	**0.022**

Legend: ventricular septal defect (VSD); kilograms (Kg); milligrams (mg); nanograms (ng); deciliters (dL); percentage (%); beats per minute (bpm); oxygen saturation (SpO2); millimeters (mm); ejection fraction (EF); mitral insufficiency (MI); respiratory frequence (RF); heart rate (HR); number (n°); C-reactive protein (CRP); mean corpuscular volume (MCV).

Table 1: General characteristics according to Ross functional class

Length of stay and follow-up

From the analysis of the collected data, it emerged that the median duration of hospitalization for the whole sample was 15±7 days; while the length of stay in the Post-Operative Intensive Care Unit (PO-ICU) was approximately 2±1. Regarding to subsequent hospitalizations, these affected 5% of the sample (n=3/57), while the main cause was attributed for the most part (2/3) to complications relating to the sternal wound and in only one case for therapeutic re-modulation following the appearance of pericardial effusion. The follow-up data, divided by Ross Functional Class, are shown in Table 1 (own production).

Correlation between Ross Functional Class and days of hospitalization

Patients with Ross Functional Class 2 and 3 had a longer hospital stay than patients in functional class 1 (Log-rank test < 0.001) (Figure 2). Furthermore, patients with a higher functional class (3) demonstrated a greater relative risk (risk-ratio, RR) of total hospital stay and of PO-ICU hospitalization – Table 2 (own production).

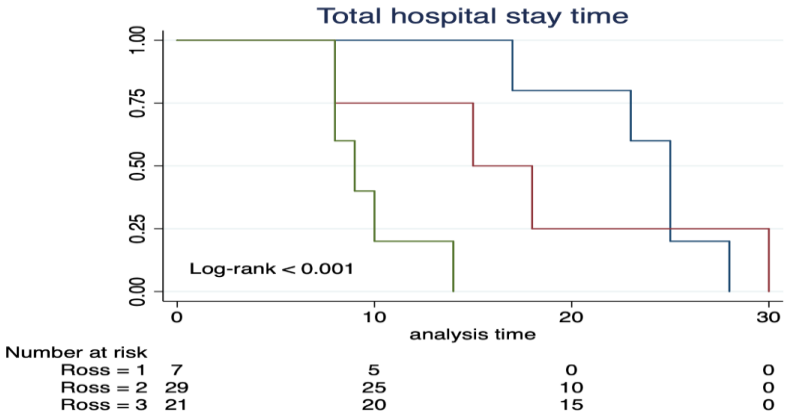

Figure 2: Kaplan-Meier curves of total hospital stay by Ross functional class (self-produced figure).

Table 2. Correlation between Ross functional class and days of hospitalization in PO-ICU and total hospitalization

Length of hospital stay			
Ross functional class	**RR**	**[95% Conf. Interval]**	**P-Value**
Ross class 2	1.85	0.73, 1.98	0.029
Ross class 3	1.56	0.41, 1.77	0.000
Length of stay in PO-ICU			
Ross functional class	**RR**	**[95% Conf. Interval]**	**P-Value**
Ross class 2	1.26	0.09, 1.69	0.007
Ross class 3	1.17	0.05, 1.51	0.002

Legend: post-operative intensive care unit (PO-ICU); risk ratio (RR); confidence (conf.).

Table 2: Correlation between Ross functional class and days of hospitalization in PO-ICU and total hospitalization

DISCUSSION

The study shows how patients with a higher Ross Functional Class (worse clinical condition) presented more frequently and statistically significant respiratory distress and pauses during feeding.

These data confirm that the association of a higher heart rate, a reduced left ventricular ejection fraction and mitral insufficiency constitute a typology of patients with a serious clinical condition [9][10]. Patients with Ross Functional Class 2 and 3 required a prolonged intra-hospital path for more intensive therapeutic treatments (Table 1).

This severity led to surgical intervention with the risk of further burdening the clinical conditions of the child and family management given the type of necessary procedure [11].

Specifically, 7 patients faced surgical reoperation.

In this context, the clinical and advanced skills of the nursing staff become crucial, where even the communication impossibility of the little patients admitted to the ICU does not allow a specific anamnestic collection of the symptoms at onset.

Furthermore, collecting specific data such as feeding time, recording of food breaks and respiratory distress, when integrated with medical data, allows for a more accurate assessment of heart failure and allows the latter to be diagnosed perhaps even before clinical-instrumental parameters.

CONCLUSIONS

The detection of the Functional Class for heart failure in pediatric age, if implemented in daily clinical practice, could favor the early recognition of pediatric patients at risk of heart failure.

It would also allow to undertake an adequate and synergistic therapeutic path between the various healthcare professionals in the pediatric cardiology and cardiac surgery departments, so as to have an effective comparison on the clinical situation of the involved patient and allow an excellent care level.

As regards future research, evaluating the use of the Ross Classification over time on young patients at risk of heart failure would help to better understand the effectiveness of nursing care with consequences on the organization of the clinical-care path.

Finally, as regards the limitations of the study, a possible limit is the recently pandemic period which may have reduced the sample size, since was noted a reduction in the number of outpatient visits for the first pediatric cardiologic screening check-up and concomitant reticence to the hospitalization by the parents of the patients for elective surgeries that can be postponed.

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