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ORIGINAL ARTICLE

Early echocardiographic evaluation of children admitted to the emergency department for anorexia nervosa during the COVID-19 pandemic

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Abstract

Purpose Anorexia nervosa (AN) is the most frequent eating disorder (ED), whose cardiac complications may have life-threatening consequences for both the physical and psychological health of affected children. In this study, we reported and analysed the echocardiographic anomalies found in pediatric patients diagnosed with AN.

Methods We reported the demographic and clinical characteristics of children aged 8 to 18 years, who were diagnosed with AN and underwent a complete cardiological evaluation at the Emergency Department of the Bambino Gesù Children's Hospital, IRCCS, Rome between the 1st January 2021 and the 30th June 2021. Furthermore, we compared the patients according to the presence of pericardial effusion and a BMI (body mass index) cut-off 14.5 kg/m^2.

Results Forty-nine patients were included in the study. The mean age was 15.1 years. Most patients were female (89.8%). The mean length of hospitalization was 18 days. The mean BMI at admission was 14.8 kg/m^2, with a median weight loss of 9 kg in the last year. Eleven patients (22.4%) presented with cardiovascular signs or symptoms at admission. Most patients had pericardial effusion on heart ultrasound, with a mean thickness of 6 mm (SD ± 4). The LV (left ventricle) thickness over age was significantly higher in patients with pericardial effusion, with a *Z* score of −2.0 vs −1.4 ($p = 0.014$). The administration of psychiatric drugs was significantly more frequent in patients with a lower BMI (37.5% vs 12%, $p = 0.038$).

Conclusion Our study suggests that a non-urgent baseline echocardiographic evaluation with focus on left-ventricular wall thickness and mass in children with anorexia nervosa is advisable.

Level III Evidence obtained from cohort or case-control analytic studies.

Keywords Anorexia nervosa · Feeding and eating disorders · Cardiovascular abnormalities · Child · Adolescent · Echocardiography

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Introduction

Eating disorders (ED) are chronic illnesses with potentially life-threatening consequences for both physical and psychological health. Anorexia nervosa (AN) represents the most frequent eating disorder, with a lifetime prevalence of 0.1–3.6% [1] and a median age of onset of 18 years [2]. AN is characterized by body image distortion and incessant search for extreme thinness; this ideal condition could be achieved through a restriction of caloric intake/excessive exercise (restrictive subtype) or by means of periodic "binge eating" associated with emptying practices such as induction of vomiting and intake of diuretic or laxatives (bulimic/purgative subtype) [3, 4]. Among the psychiatric disorders encoded by the DSM-V classification, AN is the one characterized by the highest mortality rate (5.1 deaths/1000/year), with deaths related to both suicide and medical complications [5]. It is estimated that up to 5.9% of mortality in AN is caused by cardiovascular complications, mainly sudden cardiac death due to QTc prolongation leading to ventricular arrhythmias [6, 7]. This is remarkable, if one considers that 80% of anorexic patients develop cardiovascular abnormalities due to weight loss and malnutrition [8–12]. The specific physio-pathological mechanisms leading to the cardiac changes observed in AN are still not fully understood, as well as their correlation with BMI, amount of weight loss and laboratory markers (electrolytes, serum proteins, hormones like FT4 e IGF1) [13–16]. On the other hand, refeeding seems to lead to normalisation of such alterations in most affected people [17–21]. In addition, the increased stress caused by the COVID-19 pandemic and the collective restrictions imposed by the government in attempts to limit the spread of the disease has affected children's mental health [22]. In this setting, the increased number of young people is requiring admission to health-care services, because of ED has been linked to the onset of a real "ED epidemic" within the COVID-19 pandemic [23, 24]. In particular, recent studies showed a more acute and severe ED onset during COVID-19 pandemic than in the recent past as well as an increased rate of psychiatric comorbidities and use of psychotropic drugs and a higher proportion of hospitalization [25, 26].

The purpose of the present study was to early assess ecocardiographic evaluation in patients diagnosed with AN admitted at ED during COVID-19 pandemic period and report the main echocardiographic anomalies correlating with the clinical and demographic characteristics of our sample.

Methods

We conducted a retrospective study on all pediatric patients with a diagnosis of AN (according to DSM-V criteria) who accessed the Emergency Department of the Bambino Gesù Children's Hospital, IRCCS, Rome between the 1st January 2021 and the 30th June 2021, during COVID-19 pandemic. Patient data were obtained by clinical chart review. We included patients aged 8–18 years with a diagnosis of restrictive or binge-eating/purging AN, who underwent a complete cardiological evaluation (electrocardiogram—ECG—and echocardiography with Doppler ultrasound) at admission to the Emergency Department of our Institution. All the patients included in the study performed an echocardiographic evaluation at admission in ED.

The exclusion criteria were: age < 8 years and > 18 years; diagnosis of AN without a complete cardiological evaluation at admission. For each patient, the following clinical data were reported: auxological parameters, including age, gender, length of hospitalization, BMI (both discrete value and relative percentile), reported weight loss before admission in the last year, reported duration of weight loss; use of psychiatric drugs; cardiovascular signs and symptoms, including syncope, thoracic pain, splitted II heart tone; vital signs, including heart rate, systolic (SAP) and diastolic (DAP) arterial pressure; QT interval corrected according to Bazett's formula (QTc); heart ultrasound parameters, including presence and thickness of pericardial effusion, LV function expressed by shortening fraction (SF) related to age, right-ventricular (RV) function evaluated by tricuspid annular plane systolic excursion (TAPSE), LV thickness related to age, LV mass related to body surface area (BSA) according to Haycock, frequency of patients with a normal ventricular mass (VM), mitral valve prolapse (MVP), mitral valve arching, and mild mitral insufficiency; laboratory workup, with serum dosage of B-type natriuretic peptide (BNP), N-terminal pro-B-type natriuretic peptide (NT-pro BNP), high-sensitivity troponin (Hs-troponin), proteins, albumin, azotemia, creatinine, electrolytes, creatine phosphokinase (CPK), thyroid-stimulating hormone (TSH), and thyroxine (T4). All electrocardiographic and echocardiographic exams were performed and interpreted by the same cardiologist to reduce inter-operator variability. All data were gathered and stored in an electronic database.

We performed three different analyses on the gathered data. First, we conducted bivariate comparison between the heart ultrasound parameters reported and the remaining clinical and demographic variables of the patients. Second, we compared patients with and without pericardial effusion. Third, we conducted a comparison between patients with a BMI cut-off above and below 14.5 kg/m^2. The software IBM SPSS version 23.0 was used for statistical analysis. Continuous normally distributed variables were expressed as means and standard deviations and analysed with the Student's *T* test. Continuous non-normally distributed variables were expressed as medians and ranges and analysed with the Mann–Whitney *U* test. Categorical variables were expressed as proportions and percentages and analysed with

the Chi-squared test or Fisher's exact test (when appropriate). A p value less than 0.05 was considered statistically significant.

This study was approved by the Ethics Committee of our Children's Hospital according to the Declaration of Helsinki (as revised in Seoul, Korea, October 2008).

Results

Forty-nine patients were included in the study. The demographic and clinical characteristics of the patients, as well as cardiovascular and laboratory parameters, are outlined in Table 1.

The mean age was 15.1 years (IQR 3.0 years). Most patients were female ($n=44$, 90%). The mean length of hospitalization was 18 days. The mean BMI at admission was 14.8 kg/m^2, with a median weight loss of 9 kg in the last year. Twelve patients (25%) were taking psychiatric drugs at admission: the majority of them ($n=9$, 18%) was taking aripiprazole. Eleven patients (22%) presented with cardiovascular signs or symptoms, mostly with syncope ($n=8$, 16%). The median heart rate was 52 bpm (IQR 12). The values of the arterial blood pressure and QTc were within the range of normality. The majority of our population ($n=32$, 65%) had pericardial effusion on heart ultrasound, with a mean thickness of 6 mm (SD ± 4). The mean LV function by SF was 37% (SD ± 5). The mean TAPSE was 21 mm (SD ± 3). The mean Z scores of the LV thickness over age and the LV mass over BSA was −1.8 (SD ± 0.8) and −2.1 (SD ± 0.9). The VM was normal in 22 patients (45%). MVP and mitral arching were recorded in 5 (10%) and 10 (20%) patients, respectively. A mild mitral insufficiency was found in 22 patients (45%). The evaluated laboratory tests were found normal in all cases.

The clinical and demographic characteristics of patients with and without pericardial effusion are summarised in Table 2.

A similar distribution of age was found in the two subgroups. Length of hospitalization, BMI, and weight loss were not significantly different between the two groups. We found no significant differences in the presence of cardiovascular signs and symptoms on admission between patients with and without pericardial effusion (25.0% vs 17.6%, respectively, $p=0.725$). Heart rate, arterial blood pressures, and QTc did not differ significantly between the two groups. Among the heart ultrasound parameters analysed, only the LV thickness over age was significantly higher in patients with pericardial effusion, with a Z score of −2.0 vs −1.4 ($p=0.014$). All the remaining variables were similar between the two groups, with the exception of the median TSH that was higher in patients with pericardial effusion ($p=0.001$), although still within normal ranges.

Table 1 Clinical and demographic characteristics of study sample

Total	49
Age—median (IQR)	15.1 (3.0)
Females—no. (%)	44 (89.8)
Male to female ratio	1:8.8
Length of hospitalization (days)—median (IQR)	18 (19)
BMI (kg/m^2)—mean (SD)	14.8 (2.1)
BMI (percentile)—median (IQR)	0.5 (5.5)
Weight loss (kg)—median (IQR)	9.5 (8.8)
Weight loss (months)—median (IQR)	3.0 (4.0)
Psychiatric drugs—no. (%)	12 (24.5)
Aripiprazole	9 (18.4)
Sertraline	5 (10.2)
Benzodiazepines	4 (8.2)
Olanzapine	2 (4.1)
Mirtazapine	1 (2.0)
Cardiovascular signs and symptoms—no. (%)	11 (22.4)
Syncope—no. (%)	8 (16.3)
Thoracic pain—no. (%)	2 (4.1)
Splitted II heart tone—no. (%)	1 (2.0)
Vital signs	
Heart rate—median (IQR)	52 (12)
SAP (mmHg)—mean (SD)	103 (9.5)
DAP (mmHg)—mean (SD)	65 (7.6)
QTc—mean (SD)	393 (27)
Heart ultrasound	
Pericardial effusion—no. (%)	32 (65.3)
Pericardial effusion (mm)—mean (SD)	6 (4)
LV function (SF, mm over age %)—mean (SD)	37 (5)
RV function (TAPSE, mm)—mean (SD)	21 (3)
LV thickness over age (Z score)—mean (SD)	−1.8 (0.8)
LV mass over BSA (Z score)—mean (SD)	−2.1 (0.9)
Normal VM—no. (%)	22 (44.9)
PVM—no. (%)	5 (10.2)
Arching—no. (%)	10 (20.4)
Mild mitral insufficiency—no. (%)	22 (44.9)
Laboratory workup	
BNP—mean (SD)	89.9 (49.9)
NT-pro BNP—median (IQR)	68.6 (169.1)
Hs-troponin—median (IQR)	4.0 (3.2)
Proteins (g/dl)—mean (SD)	7.0 (0.5)
Albumin (g/dl)—mean (SD)	4.7 (0.4)
Azotemia (mg/dl)—mean (SD)	13.6 (5.9)
Creatinine (mg/dl)—mean (SD)	0.76 (0.18)
Sodium (mEq/l)—median (IQR)	139 (2)
Potassium (mEq/l)—median (IQR)	4.4 (0.5)
Calcium (mg/dl)—mean (SD)	9.6 (0.4)
Magnesium (mg/dl)—median (IQR)	2.2 (0.2)
CPK (U/l)—median (IQR)	70 (41)
TSH (mcU/ml)—median (IQR)	2.08 (1.97)
FT4 (ng/dl)—mean (SD)	1.12 (0.24)

Table 2 Clinical and demographic characteristics of patients by pericardial effusion

Pericardial effusion	Present	Absent	*P* value
Total	32	17	–
Age—median (IQR)	15.0 (2.8)	15.4 (3.4)	0.737
Females—no. (%)	30 (93.8)	14 (82.4)	0.326
Male to female ratio	1:16	1:4.6	–
Length of hospitalization (days)—median (IQR)	18 (25)	22 (18)	0.338
BMI (kg/m^2)—mean (SD)	14.9 (2.1)	14.6 (2.0)	0.639
BMI (percentile)—median (IQR)	0.8 (8.4)	0.3 (2.7)	0.573
Weight loss (kg)—median (IQR)	10 (9)	9 (10)	0.877
Weight loss (months)—median (IQR)	3 (5)	2 (4)	0.225
Psychiatric drugs—no. (%)	7 (21.9)	5 (29.4)	0.729
Aripiprazole	5 (15.6)	4 (23.5)	0.700
Sertraline	4 (12.5)	1 (5.9)	0.646
Benzodiazepines	1 (3.1)	3 (17.6)	0.114
Olanzapine	0 (0)	2 (11.8)	0.116
Mirtazapine	0 (0)	1 (5.9)	0,.347
Cardiovascular signs and symptoms—no. (%)	8 (25.0)	3 (17.6)	0.725
Syncope—no. (%)	6 (18.7)	2 (11.8)	0.696
Thoracic pain—no. (%)	2 (6.3)	0 (0)	0.537
Splitted II heart tone—no. (%)	0 (0)	1 (5.9)	0.347
Vital signs			
Heart rate—median (IQR)	51 (11)	54 (27)	0.521
PAS (mmHg)—mean (SD)	104 (10)	101 (9)	0.212
PAD (mmHg)—mean (SD)	66 (7)	63 (8)	0.144
QTc—mean (SD)	399 (20)	387 (36)	0.247
Heart ultrasound			
LV function (mm over age %)—mean (SD)	38 (4)	36 (7)	0.324
RV function (TAPSE mm)—mean (SD)	20 (3)	21 (3)	0.895
LV thickness over age (Z score)—mean (SD)	−2.0 (0.8)	−1.4 (0.7)	**0.014**
LV mass over BSA (Z score)—mean (SD)	−2.1 (1.0)	−2.0 (0.8)	0.721
Normal VM—no. (%)	15 (46.9)	7 (41.2)	0.702
PVM—no. (%)	4 (12.5)	1 (5.9)	0.646
Arching—no. (%)	8 (25.0)	2 (11.8)	0.459
Mild mitral insufficiency—no. (%)	15 (46.8)	7 (41.2)	0.702
Laboratory workup			
BNP—mean (SD)*	95.5 (50.6)	58.4 (38.2)	0.245
NT-pro BNP—median (IQR)*	206.0 (183.5)	35.7 (–)	0.121
Hs-troponin—median (IQR)*	4.2 (3.9)	3.9 (4.0)	0.826
Proteins (g/dl)—mean (SD)	7.0 (0.5)	7.0 (0.6)	0.873
Albumin (g/dl)—mean (SD)	4.8 (0.4)	4.7 (0.3)	0.284
Azotemia (mg/dl)—mean (SD)	14.4 (6.2)	12.0 (5.0)	0.169
Creatinine (mg/dl)—mean (SD)	0.8 (0.2)	0.7 (0.2)	0.479
Sodium (mEq/l)—median (IQR)	140 (3)	139 (2)	0.905
Potassium (mEq/l)—median (IQR)	4.4 (0.6)	4.4 (0.5)	0.842
Calcium (mg/dl)—mean (SD)	9.6 (0.3)	9.6 (0.6)	0.902
Magnesium (mg/dl)—median (IQR)	2.2 (0.1)	2.1 (0.2)	0.052
CPK (U/l)—median (IQR)	74 (50)	63 (48)	0.136
TSH (mcU/ml)—median (IQR)	2.87 (2.19)	1.60 (0.94)	**0.001**
FT4 (ng/dl)—mean (SD)	1.09 (0.26)	1.15 (0.21)	0.532

Significant values are in bold

*Sparse data

The clinical and demographic characteristics of patients stratified according to a BMI cut-off of 14.5 kg/m^2 are summarised in Table 3.

Demographic data, vital signs, cardiovascular signs and symptoms, and heart ultrasound parameters were not significantly different between the two groups. The administration of psychiatric drugs was significantly more frequent in patients with BMI below the cut-off (38% vs 12%, $p=0.038$). We also found a significantly lower value of proteins, creatinine, calcium, and CPK in patients with a lower BMI, although still within normal ranges.

Discussion

Our results confirmed the strict connection between AN, weight loss, and the reduction of LV mass. In particular, we showed an LV wall thickness and LV mass decrease of −1.8 and −2.1 of *Z* score, respectively. These data were not significant when considering the differences between patients with a BMI below or above the chosen cut-off of 14.5.

This is in line with the literature, where a lower BMI reflects a lower LV mass index, as well as a smaller LV mass: in fact, a decrease in LV mass ranging from 30 to 50% has been described [27]. These data suggest that cardiac volume is initially reduced in severe AN, although this alteration is apparently reversible [28–30]

In addition, we found that the majority of patients with AN had pericardial effusion (65.3%), although this was not significantly associated with any of the reported variables, except for a reduced LV thickness over age (*Z* score −2.0 vs −1.4, $p=0.014$). In the study by Docx et al. [26], 29 of the 128 (22.7%) adolescent girls with AN included had pericardial effusion, which was significantly associated with lower BMI and LV mass, contrary to our results. Similarly to our study, Kastner et al. [21] found a significant but little difference in the BMI of anorexic girls with or without pericardial effusion. Interestingly, the longitudinal evaluation of these patients proved that patients with pericardial effusion required longer hospitalization and had a remarkable, significant weight gain, compared to patients without pericardial effusion. This suggests a relationship of pericardial effusion with the difference between desired and actual BMI—rather than with the "point-of-care" BMI—that has not yet been proven. However, a proxy of this measure that we have included in our analysis, that is the severity and time of weight loss, also failed to correlate with pericardial effusion. A recent 20-year-long longitudinal study on 29 women diagnosed with AN during their adolescence did not report pericardial effusion among the echocardiographic variables (Fig. 1) [31].

The higher rate of pericardial involvement in our patients may be due to a more severe clinical status of these patients, owing to the delayed referral caused by the COVID-19 pandemic [25]. None of our patients reported cardiac tamponade, which is considered by the literature a very rare complication in this group of patients [32].

Moreover, a statistically significant difference was found between the presence of pericardial effusion in our AN population and increased TSH ($p<0.001$), similar to previous research that reported this connection with T3 hormone levels [26]; however, we did not measure T3 hormone levels as this is increasingly converted to reverse T3 under semi-starvation [33].

Another cardiac complication documented in patients with AN has been mitral valve disease. Although an incidence of mitral valve prolapse in AN ranging from 33 to 60% [34] has been recorded in the literature, arching of the superior leaflet, which is the echocardiographic counterpart of angiographically defined prolapse [35], was reported in 20% of our sample. According to this definition, no mitral valve prolapse was detected by Borgia et al. in their sample of 38 children and adolescents with anorexia nervosa [36]. Nonetheless, a similar rate of mitral regurgitation (50%) was observed compared to our sample (45%) (Fig. 2).

AN and cardiac abnormalities have been linked to electrolyte alterations, such as hypophosphatemia, hypokalemia, and hypocalcemia. [35, 36]. Our results showed a reduction in average sodium, potassium, phosphate, and calcium values below or above the chosen BMI cut-off of 14.5, with no statistical differences. Early detections of these changes are fundamental to limit worsening of clinical status.

Although AN has been linked to cardiac complications and increased morbidity, these are reversible in most cases, with weight recovery [18]. Our study did not focus on the recovery aspects, and this may be called a limitation, yet our goal was to identify early cardiac involvement in AN to manage these patients early. Further long-term prospective studies on the effects of weight recovery in such patients should consider both echocardiographic and MRI parameters to investigate any long-term effect, such as myocardial fibrosis, as suggested in the literature [37]. Moreover, clinicians should be aware of refeeding syndrome and congestive heart failure, as described in previous findings [38].

Our study period goes from January 1, 2021 to June 30, 2021 and overlaps with the SARS-CoV-2 pandemic. Although recent reports have documented cardiac abnormalities during the pandemic, such as pericardial effusion and left-ventricular dysfunction [39], we could not confirmed these findings in our sample, as all of our patients were tested for SARS-CoV-2 and found negative at the time of admission.

Table 3 Clinical and demographic characteristics of patients by the BMI cut-off of 14.5

BMI	< 14.5	≥ 14.5	*P* value
Total	**24**	**25**	–
Age—median (IQR)	14.5 (3.1)	15.1 (3.3)	0.363
Females—no. (%)	21 (87.5)	23 (92.0)	0.667
Male to female ratio	1:7	1:11.5	
Length of hospitalization (days)—median (IQR)	24 (21)	18 (25)	0.104
Weight loss (kg)—median (IQR)	9.5 (15)	9.5 (7)	0.758
Weight loss (months)—median (IQR)	3 (6)	3 (5)	0.802
Psychiatric drugs—no. (%)	9 (37.5)	3 (12.0)	**0.038**
Aripiprazole	6 (25.0)	3 (12.0)	0.289
Sertraline	3 (12.5)	2 (8.0)	0.667
Benzodiazepines	3 (12.5)	1 (4.0)	0.349
Olanzapine	2 (8.3)	0 (0)	0.235
Mirtazapine	1 (4.2)	0 (0)	0.490
Cardiovascular signs and symptoms—no. (%)	4 (16.7)	7 (28.0)	0.339
Syncope—no. (%)	4 (16.7)	4 (16.0)	1.000
Thoracic pain—no. (%)	0 (0)	2 (8.0)	0.490
Splitted II heart tone—no. (%)	0 (0)	1 (4.0)	1.000
Vital signs			
Heart rate—median (IQR)	56 (18)	50 (9)	0.075
PAS (mmHg)—mean (SD)	101 (9)	105 (9)	0.126
PAD (mmHg)—mean (SD)	65 (7)	65 (8)	0.780
QTc—mean (SD)	396 (7)	394 (24)	0.862
Heart ultrasound			
Pericardial effusion—no. (%)	13 (54.2)	19 (76.0)	0.140
Pericardial effusion (mm)—mean (SD)	5 (4)	7 (3)	0.221
LV function (mm over age %)—mean (SD)	38 (4)	37 (7)	0.702
RV function (TAPSE mm)—mean (SD)	20 (3)	21 (3)	0.187
LV thickness over age (Z score)—mean (SD)	−1.8 (0.9)	−1.8 (0.7)	0.967
LV mass over BSA (Z score)—mean (SD)	−2.1 (0.8)	−2.0 (1.0)	0.755
Normal VM—no. (%)	11 (45.8)	11 (44.0)	0.897
PVM—no. (%)	4 (16.7)	1 (4.0)	0.189
Arching—no. (%)	2 (8.3)	8 (32.0)	0.074
Mild mitral insufficiency—no. (%)	11 (45.8)	11 (44.0)	0.897
Laboratory workup			
BNP—mean (SD)*	104 (48)	81 (51)	0.330
NT-pro BNP—median (IQR)*	206 (–)	44 (172)	0.289
Hs-troponin—median (IQR)*	4.1 (5.3)	4.0 (2.8)	0.510
Proteins (g/dl)—mean (SD)	6.8 (0.4)	7.3 (0.5)	**0.001**
Albumin (g/dl)—mean (SD)	4.7 (0.3)	4.8 (0.4)	0.337
Azotemia (mg/dl)—mean (SD)	13.8 (6.0)	13.4 (5.9)	0.781
Creatinine (mg/dl)—mean (SD)	0.7 (0.2)	0.8 (0.2)	**0.043**
Sodium (mEq/l)—median (IQR)	139 (1)	140 (3)	0.522
Potassium (mEq/l)—median (IQR)	4.4 (0.5)	4.5 (0.5)	0.294
Calcium (mg/dl)—mean (SD)	9.5 (0.4)	9.8 (0.6)	**0.024**
Magnesium (mg/dl)—median (IQR)	2.2 (0.1)	2.2 (0.2)	0.336
CPK (U/l)—median (IQR)	64 (37)	88 (69)	**0.036**
TSH (mcU/ml)—median (IQR)	2.04 (2.15)	2.31 (2.37)	0.291
FT4 (ng/dl)—mean (SD)	1.12 (0.20)	1.11 (0.29)	0.978

Significant values are in bold

*Sparse data

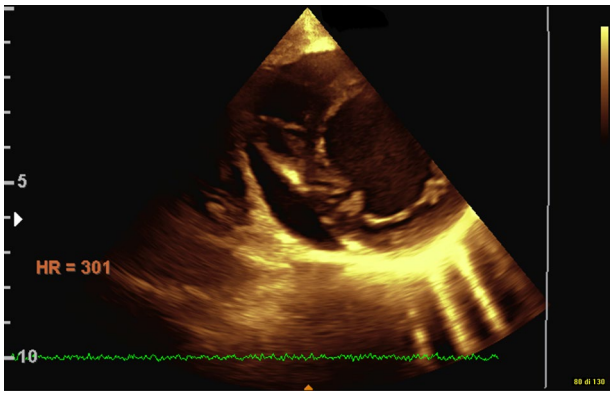

Fig. 1 Pericardial effusion

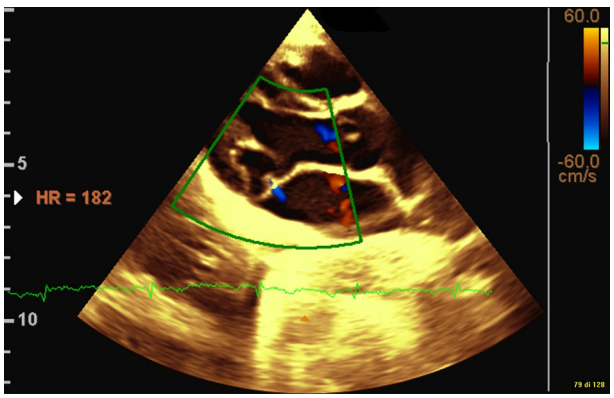

Fig. 2 Mitral valve arching

Strengths and limitations

Our study described cardiologic abnormalities in a sample of pediatric patients with AN in an emergency setting, while most research has focused on adults and children, followed-up prospectively. We also limited inter-operator variability by recruiting a single pediatric cardiologist to perform all echocardiographic studies. Finally, patients included in our study were admitted to the emergency department during the COVID-19 pandemic, which may have contributed to the increased severity of presentation and the observed echocardiographic changes. However, all patients in our sample were screened for SARS-CoV-2 infection and proved negative, thus eliminating the bias of COVID-19 as a possible direct cause of the echocardiographic anomalies observed. However, our study is limited by its retrospective nature and the lack of sample size estimation, which may have underpowered our analysis.

Conclusion

Pediatric AN is known to be associated with cardiac complications that may require immediate, noninvasive evaluation upon admission to the emergency department and close monitoring after patient recovery and weight gain. Our study suggests that a non-urgent baseline echocardiographic evaluation with focus on left-ventricular wall thickness and mass in children with anorexia nervosa is advisable, as a putative association with cardiovascular complications and death may be proved in further prospective studies.

What is already known on this subject?

Cardiological complications of AN, evident electro- or echocardiographically, have been described in the literature as a consequence of both malnutrition and weight regain.

What does this study add?

This study emphasizes the importance of early assessment of cardiologic function in patients with AN as early as admission to the emergency department. It also describes cardiologic changes in a pediatric population with AN, adding data and information to the literature on this special group of patients.

We believe that our findings may also be of great use to the wide community of pediatricians and other specialists involved in this specific area of children's care.

Author contributions All authors conceived the study concept. GS, AC, MR, MRM, UR, and AA designed the study, were major contributors in writing the manuscript, contributed to the interpretation of the data, reviewed and revised the manuscript; MR performed statistical analysis; PS, CM allowed for the acquisition of data, and reviewed and revised the manuscript; VZ, AD, AR, and AV revised the manuscript for important intellectual content, and reviewed and critically revised the manuscript for important intellectual content; AV coordinated the study; all authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

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Availability of data and materials The datasets are available from the corresponding author on reasonable request.

Code availability The source codes are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors have no conflicts of interest to disclose.

Ethical approval This retrospective chart review study involving human participants was in accordance with the ethical standards of the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Ethical approval was granted by the Research Ethics Board at the Bambino Gesù Children's Hospital, IRCCS, Rome, Italy.

Informed consent Informed consent was not required, given the retrospective nature of the study and the completely anonymous treatment of the data.

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