


# Non-specific aortoarteritis (NSAA) in children: a prospective observational study

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## ABSTRACT

**Objective** Prospective data on clinical profile, natural history and outcomes of NSAA (non-specific aortoarteritis) in children is limited. We initiated this prospective study to evaluate the short-term and medium-term outcomes of NSAA in children.

**Design** Prospective observational study.

**Setting** Tertiary care hospital in India.

**Patients** We included 28 consecutive children (<15 years) with a diagnosis of NSAA.

**Main outcome measures** Clinical profile, symptoms, left ventricular ejection fraction (LVEF), the pattern of vessel involvement, complications and markers of disease activity were assessed at the time of diagnosis. All the patients underwent treatment and interventions as per the current guidelines and were followed up for a mean duration of 13.5±6.7 months for disease activity and outcomes.

**Results** The mean age of the cohort was 10±2.9 years (14 boys). Twenty (71%) patients had hypertension. Half of the children presented with acute decompensated heart failure (ADHF). Only 21 patients (75%) met Sharma *et al* modified Ishikawa criteria for the diagnosis. The children with active disease (36%) were managed with immunosuppressive drugs. Percutaneous and surgical interventions were performed in 26 (93%) children. New York Heart Association functional class, LVEF and control of hypertension improved in most children on follow-up. Four children developed vascular restenosis requiring reinterventions. There was no death during mid-term follow-up.

**Conclusions** Children with NSAA, unlike adults seldom present with classical features of the disease. ADHF and ventricular dysfunction are strikingly common in children. Appropriate immunosuppressive therapy for active disease and timely intervention improves clinical outcomes over a medium term follow-up. Future studies assessing long-term outcome are needed.

## INTRODUCTION

Non-specific aortoarteritis (NSAA) is a granulomatous inflammatory disease of medium to large vessels which results in stenosis, occlusion and less commonly, dilatation of involved arteries. NSAA is also known as Takayasu arteritis after Japanese ophthalmologist, M Takayasu, who described it first in 1908.<sup>1</sup> The

## What is known about the subject?

- ▶ Non-specific aortoarteritis (NSAA), though considered a disease of young adults, is the most common cause of renal vascular hypertension in children.
- ▶ The presentation of NSAA is atypical in children.

## What this study adds?

- ▶ Children often present with hypertension or acute decompensated heart failure.
- ▶ The adult diagnostic criteria for NSAA can miss the disease in as many as 25% of children.
- ▶ Appropriate medical and interventional management results in significant and sustained improvement over a medium term follow-up.

exact aetiology of the disease remains unknown. Though NSAA is primarily considered a disease of young adults, it is being increasingly recognised in children. In fact, it is one of the most common causes of renovascular hypertension in Asian children.<sup>2</sup> Unlike adults, prospective data on clinical profile, progression and outcomes in children with NSAA are limited.<sup>3 4</sup> In this prospective study, we aimed to study the presentation, course and medium-term outcomes in children with NSAA.

## METHODS

We included all consecutive children (aged <15 years) with NSAA after obtaining informed parental consent. The only exclusion criterion was parents' unwillingness to participate in the study. Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

## At presentation

Clinical profile including demographics and presenting symptoms were recorded. Physical examination included assessment of



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peripheral pulses, auscultation for bruits and four limb blood pressure (BP) measurement. The left ventricular ejection fraction (LVEF) was measured using two-dimensional echocardiography by two independent experienced operators. We measured markers of renal function and acute phase reactants (APR) including erythrocyte sedimentation rate and C reactive protein in all the children. Eighteen children suspected to have NSAA directly underwent conventional digital subtraction angiography, while 10 patients were diagnosed based on an initial abdominal ultrasound and Doppler evaluation.

### Diagnosis

Children were diagnosed to have NSAA based on typical angiographic findings in addition to clinical signs and symptoms. Based on the pattern of aortic involvement, five types were identified.<sup>5,6</sup>

### Measurement of activity

The activity of disease was assessed using US national Institute of Health (NIH) Criteria.<sup>7</sup>

### Management and follow-up

All children diagnosed to have NSAA were managed as per the current guidelines.<sup>3</sup> Those with evidence of active disease were prescribed immunosuppressive drugs, while those with critical stenotic/valvular lesions were offered appropriate interventions. Angioplasty was considered technically successful if the residual stenosis was <30% and the pressure gradient was <20 mm Hg.<sup>8,9</sup> All the patients were followed up clinically for evidence of disease activity and development/worsening of new lesions. The LVEF was re-evaluated at 6 months, while imaging and biochemical assessment for NSAA were performed as per the discretion of the treating physician.

### Statistical analysis

Continuous variables are expressed as mean and SD. Categorical values are expressed as frequency and percentages. We applied paired t-test for continuous variables and  $\chi^2$  test for categorical variables to compare measurements before and after treatment. Mean difference and 95% CI are reported as applicable. The difference is considered significant if the p value is less than 0.05. Statistical software used was SPSS Software (V.11.0, SPSS).

### Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

## RESULTS

A total of 28 children (14 boys, 50%) were included over 2 years. The mean age at presentation was  $10 \pm 2.9$  years (range 6–15 years). The most common mode of presentation was acute decompensated heart failure (ADHF)

(n=14; 50%) and hypertension (n=20, 71%) was the most frequent clinical finding. Table 1 summarises the demographic and presenting features of NSAA in our cohort. The BP in the upper and lower limbs was not different (p value: systolic and diastolic BP difference: 0.22 and 0.38, respectively). Baseline investigations are summarised in table 2. More than half the children had severe LV dysfunction and New York Heart Association (NYHA) class IV at presentation. The mean NYHA class at presentation was  $3 \pm 1.2$ .

The classical features of NSAA namely asymmetrical pulses, BP difference between upper limbs (UL) and bruits were found in 4 (14%), 6 (21%) and 8 (29%) children, respectively. While nine patients (32%) had presented with fever and arthralgia, only one patient each had carotidynia and lower limb claudication on presentation. Only 21 patients (75%) met Sharma *et al*'s modified Ishikawa criteria. The mean number of major and minor criteria met by the study population were  $1.3 \pm 0.8$  and  $2.4 \pm 0.8$ , respectively. Fifteen patients (54%) had dyspnoea on exertion for >1 month as major criteria, followed by subclavian artery (SCA) involvement in 10 patients (36%). However, all the 28 children could be classified as having NSAA according to the EULAR/PRINTO/PRES criteria for NSAA.<sup>4</sup>

Descending thoracic aorta (DTA) was the most common part of aorta involved (n=13, 46%), and renal artery was the most frequently involved major branch (n=12, 43%). Patterns of vessel involvement are represented in figure 1. The most common type of NSAA in our cohort was type 2 (n=18, 64%), followed by type 3 (n=8, 29%). Pulmonary artery involvement (type 4) was seen in only one patient and was clinically silent. Some interesting imaging patterns observed in the cohort are presented in figure 2.

Nineteen patients (68%) had  $\geq 2$  complications which included LV dysfunction, hypertension, renal failure, aortic regurgitation (AR), retinopathy and aortic aneurysm. LV dysfunction and hypertension were the most common complications, while AR was seen in six patients and abdominal aortic aneurysm and eye involvement in one patient each. Few patients presented with rarer complications of NSAA; one patient had stage-4 retinopathy with bilateral cataract, one patient presented with acute limb ischaemia due to peripheral embolisation from a large LV clot while there was one initial presentation with hypertensive encephalopathy and recurrent seizures. One child had renal dysfunction at presentation.

A total of 10 (36%) patients were diagnosed to have an active disease as per the NIH criteria (raised APR: 9, fever and arthralgia: 9, bruits: 8, arthritis: 2 and carotidynia: 1). All the patients with active disease were started on immunosuppressive drugs which included corticosteroids alone or in combination with azathioprine and/or methotrexate.

Interventions were attempted in 26 patients (93%) and was successful in 21 patients (75%). The patients with active disease were taken up for the procedure

**Table 1** Demographic and clinical characteristics of the study cohort (n=28)

Sl. no.	Characteristics	Value Mean±SD or N (%)
(1)	Age in years	10±2.9
(2)	Boys	14 (50%)
(3)	Blood pressure	
	Hypertension	20 (71%)
	Highest BP recorded UL mm Hg (mean SBP/mean DBP ±SD)	155.2±32.6/91.9±21.9
	Highest BP recorded LL mm Hg (mean SBP/mean DBP±SD)	142.3±45.4/85.5±28.9
	More than 10 mm Hg systolic BP difference between two UIs	6 (21%)
(4)	Acute decompensated heart failure	14 (50%)
	Presentation in NYHA class IV	14 (50%)
	Presentation in NYHA class III	4 (14%)
	Presentation in NYHA class II	6 (21%)
(5)	Fever and arthralgia	9 (32%)
(6)	Bruits	8 (29%)
(7)	Unequal pulses	4 (14%)
(8)	Carotidynia	1 (4%)
(9)	Non-cardiac complications of NSAA	
	Retinopathy	1 (4)
	Encephalopathy and seizures	1 (4)
	LL claudication	1 (4)
	Renal failure	1 (4)
	Abdominal aortic aneurysm	1 (4)
(10)	≥2 complications	19 (68%)

BP, blood pressure; DBP, diastolic blood pressure; LL, lower limb; LVEF, left ventricular ejection fraction; n, number; NYHA, New York Heart Association; SBP, systolic blood pressure; UL, upper limbs.

usually after remission of activity unless the presentation was ADHF. Successful percutaneous transluminal renal angioplasty (PTRA) was done in six out of nine patients (figure 3A,B), while percutaneous transluminal angioplasty (PTA) was successful in 13 out of 14 attempted procedures (figure 3C,D). PTA was unsuccessful in a

patient with arch involvement where angioplasty to right common carotid artery was attempted. Three patients required stents; two required it for a suboptimal angiographic result after balloon angioplasty and one required it for a large flow-limiting dissection (figure 3E–H). The mean aortic lumen stenosis decreased from 75±8% to 23±10% ( $p<0.0001$ ) and gradient decreased from 60±15 to 24±10 mm Hg ( $p<0.0001$ ). In the PTRA group, the stenosis decreased from a mean of 90±7% to 20±13% and the pressure gradient decreased from 70±27 to 15±10 mm Hg ( $p<0.001$ ). Three patients underwent successful surgery, out of whom two patients required aortic bypass grafting with reimplantation of renal arteries and one patient required mitral valve replacement for severe mitral regurgitation (MR).

Follow-up: Duration of follow-up ranged from 6 to 24 months with a mean of 13.5±6.7 months. Twenty-six (93%) patients were in either NYHA class 1 or 2 on follow-up as compared with 10 patients (36%) on initial presentation (figure 4). BP was well controlled in 14 (70%) patients, with 6 patients (30%) requiring only one drug and 3 patients (15%) requiring none. Mean systolic and diastolic BP decreased significantly as well as the requirement of antihypertensive drugs (table 3). LVEF

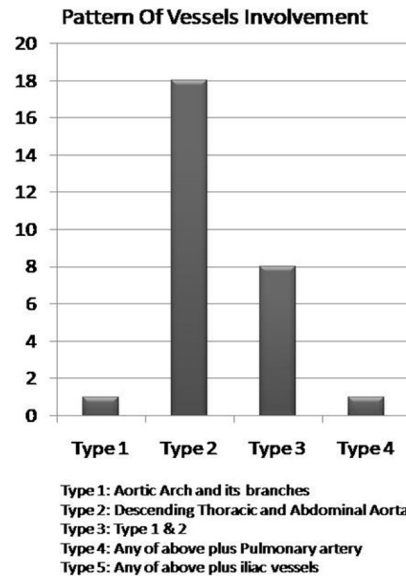
**Table 2** Baseline investigations of the study cohort (n=28)

Variable	Mean±SD or N (%)
Hb (g/L)	147.9±16.1
Platelets (lacs/dL)	2.1±0.7
Urea (mg/dL)	32.0±7.4
Creatinine (mg/dL)	0.9±0.5
LVEF (%)	37.0±18.3
LV dysfunction	19 (68%)
Severe LV dysfunction (LVEF≤30%)	15 (54%)
Moderate to severe aortic regurgitation	6 (21%)
Mitral regurgitation (more than mild)	4 (14%)

CRP, C reactive protein; ESR, erythrocyte sedimentation rate; Hb, haemoglobin; LVEF, left ventricular ejection fraction.

Vessel Involved	N	%
Descending Thoracic Aorta	13	46.4
Aortic Arch	10	35.7
Abdominal Aorta	6	21.4
Renal artery	12	42.8
B/L RA	5	17.8
Isolated Right RA	5	17.8
Isolated Left RA	2	7.1
Subclavian artery	10	35.7
B/L SCA	2	7.14
Isolated Right SCA	3	10.71
Isolated Left SCA	5	17.8
Carotid Artery (B/L)	1	3.5

Abbreviations: B/L, Bilateral; RA, Renal artery; SCA, Subclavian artery



**Figure 1** Pattern of vessel involvement observed in the study cohort.

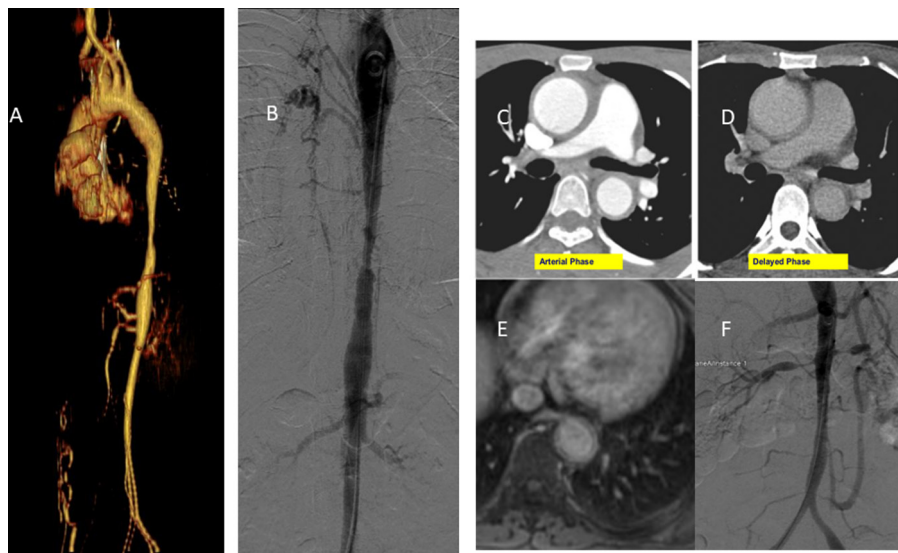
improved in 15 patients (79%) with normalisation in 5 patients (26%) patients (figure 4).

Out of 21 patients who underwent a successful intervention, 4 patients (19%) developed restenosis over the follow-up period. Three had to undergo a repeat balloon angioplasty procedure, whereas one patient had to undergo stenting. Three patients had features suggestive of disease activity at follow-up and were started on additional immunosuppressive therapy. All these three patients had activity at the initial presentation. Only two patients (7%) had evidence of new vessel involvement. One patient who initially had only arch vessel involvement had significant DTA stenosis at follow-up of 13 months. The second patient who initially had lower DTA

and left SCA stenosis developed significant narrowing of suprarenal aorta on follow-up of 12 months. There was no mortality.

## DISCUSSION

Though NSAA is considered predominantly a disease of young adults,<sup>10–12</sup> it is increasingly recognised in children.<sup>3 7 13</sup> The data on childhood NSAA have been largely retrospective with older studies focused on the presentation and course of the disease and the recent ones on follow-up of interventions and their outcome. In this study, we present the prospective data of 28 consecutive children with NSAA, their clinical presentation and



**Figure 2** Some selected illustration of imaging patterns observed in the study. (A) A CT-VRT image in sagittal oblique view showing diffuse long segment narrowing of descending thoracic aorta. (B) Corresponding catheter angiogram showing diffuse narrowing with irregular outline. CT angiography arterial (C) and delayed phase (D) images showing wall thickening with enhancement, suggestive of active disease. (E) A MRI showing diffuse wall thickening of thoracic aorta, suggestive of active disease. (F) Catheter angiogram image showing bilateral renal artery stenosis. VRT, volume rendering technique.

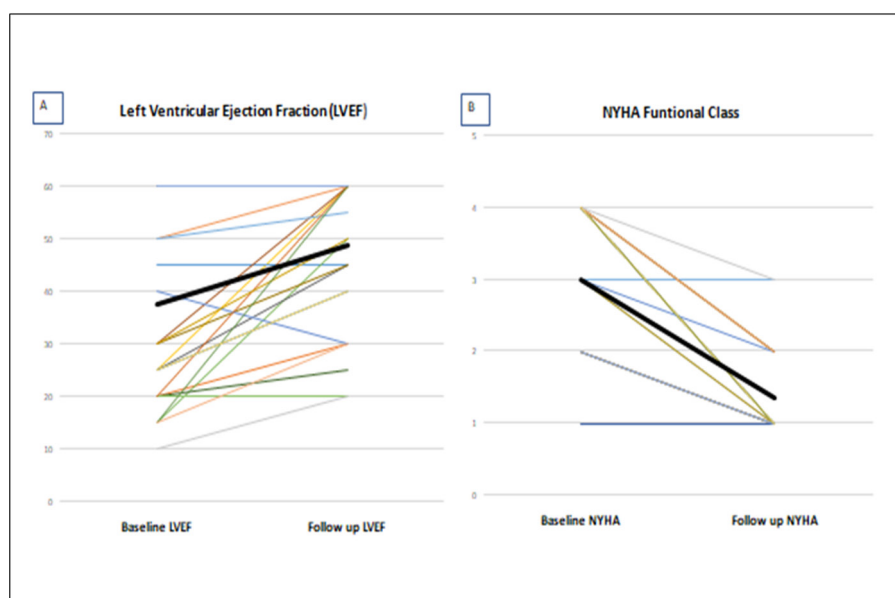


**Figure 3** (A) Right renal artery stenosis, (B) successful PTRA, (C) aortic stenosis, (D) successful PTA, (E) the lesion was dilated with an appropriate size balloon. (F) However, there was obstructive dissection, which was stented with an appropriate size stent. Check angiogram in anteroposterior (G) and lateral (H) views shows good antegrade flow with no significant stenosis. PTRA, percutaneous transluminal renal angioplasty; PTA, percutaneous transluminal aortoplasty.

mid-term follow-up, with most patients having undergone appropriate interventions.

There have been no validated diagnostic criteria for childhood NSAA.<sup>3</sup> The Ishikawa diagnostic criteria,<sup>14</sup> The American College of Rheumatology classification criteria<sup>15</sup> and Sharma's modification of Ishikawa criteria<sup>16</sup> used for diagnosis of NSAA in adults, have not been validated for childhood NSAA.<sup>3</sup> The EULAR/PRINTO/PRES classification criteria for childhood NSAA, if fulfilled, has a sensitivity and specificity of 99%.<sup>4</sup> In our cohort, only 75% of children fulfilled the diagnostic criteria as proposed by Sharma *et al*, while all the children could be classified as NSAA as per the EULAR/PRINTO/PRES classification system.

Unlike in adults, there is no female preponderance of childhood NSAA worldwide.<sup>17–19</sup> Moreover, childhood NSAA presents less commonly with classical features and more commonly with ADHF,<sup>3,20,21</sup> as demonstrated in our study also, where 50% of children had presented with ADHF. Heart failure in NSAA occurs either due to effects of uncontrolled hypertension per se or LV dysfunction secondary to uncontrolled hypertension, AR due to aortic root dilatation, valvular AR or MR, myocarditis or myocardial infarction secondary to coronary involvement.<sup>3,7,20–24</sup> Almost 75% of our patients were found to be hypertensive, which is similar to the previous series on paediatric NSAA.<sup>18,19,25</sup> Hypertension in NSAA is multifactorial and is attributed most commonly to renal



**Figure 4** (A) Left ventricular systolic function at baseline and follow-up. NYHA class (dyspnoea) at baseline and follow-up. NYHA, New York Heart Association.

**Table 3** Clinical follow-up of the study cohort (n=28)

Characteristic Mean±SD or N (%)	Baseline	Follow-up	Mean difference (95% CI)	P value
Active disease	10 (35.7)	3 (10.7)	25% (3.9, 46.1%)	0.02
NYHA functional class	3.0±1.2	1.5±0.7	-1.5 (-1.9 to -1.02)	<0.001
LVEF (%)	37.0±18.3	48.4±13.9	11.4 (5.7 to 17.2)	<0.001
Blood pressure in upper limb				
Systolic blood pressure (mm Hg)	145.8±32.5	120.4±22.7	-25.4 (-38.0 to -12.7)	<0.001
Diastolic blood pressure (mm Hg)	87.7±19.1	77.4±15.6	-10.3 (-18.8 to -1.8)	0.02
Blood pressure in lower limb				
Systolic blood pressure (mm Hg)	128.6±48.4	119.0±33.0	-8.8 (-8.5 to 26.1)	0.31
Diastolic blood pressure (mm Hg)	78.1±29.8	72.3±17.2	5.7 (-5.5 to 16.7)	0.30
New vessel involvement at follow-up	-	2 (7.1)	-	-

LVEF, left ventricular ejection fraction; NYHA, New York Heart Association.

arterial stenosis followed by aortic stenosis and increased aortic and arterial wall stiffness.<sup>3 7 9 22-25</sup> In fact, NSAA is the most common cause of renovascular hypertension among Asian children.<sup>2</sup>

The classical features of NSAA like constitutional symptoms, unequal pulses, significant BP difference between two arms and carotidynia are less commonly described in childhood NSAA.<sup>26 27</sup> The reason for this observed difference in the presentation of NSAA in children and adults is that the most frequently involved major branch in childhood NSAA is renal artery rather than SCA as demonstrated in our cohort also. In addition, children often present with BP difference between UL and LL rather than between two ULs, as the descending aorta is the most common part of the aorta involved. The most common pattern of vessel involvement seen in childhood NSAA is type II/III (thoracoabdominal aorta).<sup>19 28 29</sup> In our series, 26 (93%) patients had type II/III disease and 46% had DTA involvement. There are usually no intercostal collaterals due to the involvement of ostia of these intercostal arteries. Similarly, aneurysms do occur but rarely without stenotic lesions,<sup>26 27</sup> and in our cohort, only one child had an aneurysm. AR has been reported in 7%–15% patients of NSAA<sup>22 24 30</sup> while in our cohort, the incidence was 21% (6 patients). **Table 4** summarises the clinical profile and angiographic findings of childhood NSAA in various series.<sup>19 28 29 31-34</sup>

The most commonly used criteria to define active disease are NIH criteria.<sup>5</sup> Other scores used are Indian Takayasu Clinical Activity Score<sup>35</sup> and Disease Extent Index-Takayasu Arteritis consisting of 71 clinical entities.<sup>36</sup> Clinical activity diagnosed with NIH criteria was seen in 10 of our patients (36%) similar to the previous studies, which reported active NSAA in 30%–50% cases.<sup>19 30</sup> Most of our patients (19; 68%) had two or more complications. Severe untreated NSAA has a bad prognosis with a predicted 5-year survival rate of 70% in patients with ≥2 complications as compared with 100% in patients with no complications.<sup>30</sup>

All patients with active disease were prescribed immunosuppressive drugs. Studies have shown that 50% of the patients with NSAA respond to steroids and 50% of those unresponsive to steroids have remission of disease activity with methotrexate.<sup>3 37 38</sup> Percutaneous intervention was done in 23 children and was successful in 19. While the success rate of PTA (13/14, 93%) was comparable to that described elsewhere in the literature,<sup>8 38 39</sup> it was definitely lower for PTR (6/9, 67%) in which few studies have reported a success rate of 95%.<sup>9 40</sup> It may be due to the diffuse nature of the disease in our cohort or possibly is a reflection of small number of children in our study cohort. Like the previous studies,<sup>8 9 40</sup> we could get excellent control of BP with successful PTA and PTR. In addition to this, there was also a significant improvement in LVEF, and five patients had normalisation of LVEF on follow-up which is like the previously reported data.<sup>8 20 21</sup>

We observed restenosis in 4 (19%) patients. All patients with restenosis had initially presented with disease activity and intervention was done as an emergency measure either because of ADHF or hypertensive emergency. Saxena *et al*<sup>8</sup> and Tyagi *et al*<sup>39</sup> have reported a restenosis rate of 11.7% and 19%, respectively, at 6 months of follow-up. Only 2 patients, who had active inflammation at presentation, developed evidence of new vessel involvement on follow-up. There are no data on the incidence of new vessel involvement in children, but a large study in adults<sup>30</sup> which studied 88 patients and followed them for 83 months had shown that only 15% of patients show a change in the pattern of peripheral pulses on follow-up. The rare change in vessel involvement at follow-up may indicate a late stage of disease, with no clinical evidence of extension to previously unaffected arteries. Active disease, although, remains a risk factor for new vessel involvement. With reported mortality of 10%–30%,<sup>3 7 38</sup> NSAA remains a serious illness in children. However, there was no mortality in our cohort, which may be due to relatively shorter follow-up.

**Table 4** Clinical profile and angiographic findings of childhood NSAA

	<b>Present cohort</b>		<b>Eleftheriou et al<sup>28</sup></b>	<b>Szugye et al<sup>31</sup></b>	<b>Cakar et al<sup>34</sup></b>	<b>Jain et al<sup>33</sup></b>	<b>Muranjan et al<sup>29</sup></b>	<b>Hahn et al<sup>19</sup></b>	<b>Hong et al<sup>32</sup></b>
Year of publication	2021	2015	2014	2008	2000	2000	2000	1998	1992
Region	India	UK	USA	Turkey	India	India	India	South Africa	Korea
Number of patients	28	11	21	19	24	17	31	31	70
Age at presentation: mean (years)	10	11.8	13	12.84	14	9.3	8.4	8.4	9.4
Sex (F:M)	1:1	1.75:1	3.2:1	2.8:1	5:1	0.8:1	1.3:1	1.3:1	4.3:1
Fever, n (%)	9 (32.1)	4 (36)	5 (23.8)	5 (26)	1 (4)	3 (17.6)	2 (6.6)	2 (6.6)	NA
Arthralgia n (%)	9 (32.1)	1 (9)	NA	3 (16)	1 (4)	1 (5.8)	2 (6.6)	2 (6.6)	1 (1)
Unequal/asymmetrical pulses, n (%)	4 (14.3)	3 (27)	13 (61.9)	11 (58)	14 (58)	7 (41.1)	10 (32)	10 (32)	NA
More than 10 mm BP difference between the two limbs, n (%)	6 (21.4)	3 (27)	15 (71.4)	NA	NA	NA	NA	NA	NA
Bruits, n (%)	8 (28.6)	6 (54)	12 (57.1)	5 (26)	14 (58)	4 (23.5)	12 (38)	12 (38)	NA
HTN, n (%)	20 (71.4)	8 (72)	12 (57.1)	17 (89)	20 (83)	11 (64.7)	26 (84)	26 (84)	65 (93)
Headache	9 (32.1)	NA	NA	16 (84)	13 (54)	3 (17.6)	NA	NA	29 (41)
Cardiac disease / LV dysfunction, n (%)	19 (67.8)	3 (27)	NA	8 (42)	4 (17)	7 (41.1)	20 (64)	20 (64)	NA
Valvular regurgitation	10 (35.7) AR:6 MR:4	1 (9)	NA	NA	2 (8)	6 (35.2)	NA	NA	NA
ADHF, n (%)	14 (50)	2 (18)	NA	NA	4 (17)	8 (47.1)	20 (64)	20 (64)	37 (52)
Carotidynia	1 (3.5)	NA	1 (4.8)	NA	NA	NA	NA	NA	NA
Claudication	1 (3.5)	1 (9)	3 (14.2)	6 (32)	NA	NA	4 (12)	4 (12)	5 (7)
Renal failure, n (%)	1 (3.5)	1 (9)	1 (4.8)	NA	NA	NA	NA	NA	2 (2.9)
Stroke/encephalopathy, n (%)	1 (3.5)	1 (9)	NM	NM	4 (17)	4 (23.5)	7 (22)	7 (22)	15 (21)
Ocular complications, n (%)	HTR: 1 (3.5)	NM	2 (9.5)	NM	17 (70.8)	HTR: 5 (29.4)	HTR: 2 (6)	HTR: 2 (6)	NM
			TAR		TAR:				
			1 (4.5)		3 (12)				
			HTR: 1 (4.5)		HTR:14 (58)				
Raised acute phase reactants	9 (32.1)	NM	15 (71.4)	NM	11 (65)	14 (82.3)	23 (83)	23 (83)	37 (52)
Vessel involvement									
n (%)									

Continued



Table 4 Continued

	Present cohort	Eleftheriou et al <sup>28</sup>	Szugye et al <sup>31</sup>	Cakar et al <sup>34</sup>	Jain et al <sup>33</sup>	Muranjan et al <sup>29</sup>	Hahn et al <sup>19</sup>	Hong et al <sup>32</sup>
Type 1	1 (3.5)	1 (9.09)	NA	13 (68.4)	0	1 (5.8)	0	NA
Type 2	18 (64.3)	2 (18.18)	NA	4 (21.1)	1 (4)	9 (52.9)	11 (35.5)	NA
Type 3	8 (28.6)	7 (63.6)	NA	0	1 (4)	5 (29.4)	11 (35.5)	NA
Type 4	1 (3.5)	1 (9.09)	NA	2 (10.5)	7 (29)	2 (11.7)	4 (12.9)	NA
Type 5	0	0	NA	0	15 (62)	0	5 (16)	NA
Aortic arch	10 (35.7)	7 (63.6)	NA	13 (61.9)	2 (8)	NA	NA	2 (2.9)
TA	13 (46.4)	7 (63.6)	11 (52.4)	17 (80.9)	5 (21)	NA	5 (16)	39 (55.7)
AA	6 (21.4)	9 (81.8)	11 (52.4)	17 (80.9)	17 (71)	NA	13 (42)	44 (62.9)
RA	12 (42.8)	NA	16 (76.2)	14 (66.7)	11 (46)	12 (70.5)	22 (71)	34 (50)
SCA	10 (35.7)	NA	19 (90.5)	NA	10 (42)	NA	NA	30 (42.9)
Carotid artery	1 (3.5)	NA	9 (42.9)	NA	3 (12)	NA	NA	14 (20)
Aneurysm	1 (3.5)	1	NA	NA	NA	NA	NA	NA

AA, abdominal aorta; ADHF, acute decompensated heart failure; AR, aortic regurgitation; BP, blood pressure; F, female; HTN, hypertension; HTR, hypertensive retinopathy; M, male; MR, mitral regurgitation; NA, not available; RA, renal artery; SCA, subclavian artery; TA, thoracic aorta; TAR, Takayasu retinopathy.

**Limitations:** The sample size was relatively small and the follow-up of 13.5 months for a chronic inflammatory vasculitis like NSAA is rather short. Since the study was done in a tertiary care setting, children could have been picked up late in the course of disease. The diagnosis was based mostly on typical angiography findings in the presence of clinical suspicion. Follow-up imaging was done only when clinically indicated, which can also underestimate the incidence of new vessel involvement. Childhood NSAA, being an important cause of mortality and long-term morbidity, requires well planned larger and longer prospective studies.

## CONCLUSION

Children with NSAA, unlike adults, seldom present with classical features of the disease, requiring a high index of suspicion for diagnosis. Hypertension remains the most common sign at the time of presentation, and strikingly 50% of the children present with ADHF. One-third of children have active disease at presentation and almost 70% of patients had  $\geq 2$  complications. However, appropriate immunosuppressive therapy for active disease and timely successful intervention may change the course, with significant improvement in hypertension control, NYHA class and LVEF as illustrated in the prospective medium-term follow-up of the present cohort. Future prospective studies assessing long-term outcomes are needed.

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