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Young Hearts at Risk: Unveiling the Angiographic Secrets of Acute Coronary Syndrome

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Abstract

Background:

Acute coronary syndrome (ACS) among young adults, traditionally considered a condition of older populations, has increasingly emerged as a significant concern, especially in low- and middle-income countries like India. The growing prevalence of ACS in individuals under 45 years highlights the urgency for identifying risk factors and improving prevention strategies. Modifiable factors such as smoking, type 2 diabetes mellitus (T2DM), dyslipidemia, and obesity contribute to early-onset coronary artery disease (CAD) in this age group, though young adults tend to present with distinct clinical characteristics compared to older patients. This study aims to assess the clinical, demographic, and angiographic profiles of young ACS patients in South India.

Materials and Methods:

A retrospective observational study was conducted at a tertiary care hospital in South India over 2 years. The study included 402 young adults (aged 18-45 years) who underwent coronary angiography (CAG) for ACS. Data collected from electronic medical records included demographics, clinical presentation, medical history, cardiovascular risk factors, and angiographic findings. Statistical analyses were performed using SPSS, and associations between risk factors and angiographic profiles were evaluated.

Results:

The study cohort had a mean age of 39.88 ± 4.96 years, with a male predominance (79.4%). Chest pain was the most common presenting symptom (92%), followed by dyspnea and palpitations. Major cardiovascular risk factors included smoking (80.1%), dyslipidemia (77.6%), and T2DM (57.2%). Angiographic findings revealed single-vessel disease (48.3%) as the most prevalent, with left anterior descending artery (LAD) involvement being the most common. Normal coronary arteries were observed in 31.6% of patients, particularly in females.

Conclusions:

Young adults with ACS in South India exhibit a high burden of modifiable risk factors, with smoking, dyslipidemia, and diabetes being predominant. Single-vessel disease is the most common, and a notable percentage of patients have normal coronary arteries. Early identification and management of cardiovascular risk factors, along with targeted prevention strategies, are crucial for improving long-term outcomes in this demographic.

Keywords: *Young heart, Acute coronary syndrome, Angiography*

Background

Acute coronary syndrome (ACS) among young adults has emerged as a growing concern due to its significant impact on both morbidity and long-term cardiovascular outcomes. While traditionally linked to older populations, there has been a notable rise in the number of cases observed in individuals under 45 years of age [1-4]. The growing frequency of ACS in young adults is concerning, especially since this demographic has typically been considered low-risk for cardiovascular diseases. The Global Burden of Disease Study has highlighted an alarming trend of rising cardiovascular disease (CVD) prevalence among young people, especially in low- and middle-income countries like India [4]. Historically, the incidence of ACS has been higher in older individuals due to the cumulative effects of aging and prolonged exposure to risk factors.

The pathophysiology of early-onset coronary artery disease (CAD) in young adults is multifactorial, involving a combination of modifiable and non-modifiable risk factors. Well-established contributors such as type 2 diabetes mellitus (T2DM), smoking, dyslipidemia, obesity, and hypertension (HTN) significantly accelerate the development of atherosclerosis and increase the likelihood of myocardial infarction (MI) [5,6]. However, young adults presenting with ACS exhibit distinct clinical characteristics, risk factor profiles, and angiographic findings. Studies have shown that modifiable lifestyle risk factors, such as smoking and substance abuse, are more prevalent in young adults with ACS [5,6]. Unlike older patients, who typically have multi-vessel disease, younger individuals often present with single-vessel disease (SVD) and tend to have better long-term prognoses [7,8].

Particularly concerning is the relationship between T2DM and ACS, especially given the growing prevalence of diabetes in South Asian populations, where it significantly contributes to cardiovascular disease. Furthermore, obesity has been identified as an independent risk factor for cardiovascular morbidity, with elevated body mass index (BMI) serving as a predictor for ACS in younger individuals. Familial predisposition plays a crucial role in premature CAD, with studies highlighting a positive family history in 39-41% of young ACS patients, suggesting both genetic and environmental factors at play. The risk factor profile for young adults with ACS diverges from that of older populations, with a higher prevalence of smoking, sedentary behavior, alcohol consumption, elevated triglycerides, and lower levels of high-density lipoprotein (HDL) cholesterol.

While young ACS patients typically exhibit better in-hospital outcomes due to less extensive coronary artery involvement and superior myocardial recovery, the long-term prognosis remains worrisome. Survivors of young MI are at an increased risk for recurrent cardiovascular events, peripheral vascular disease, and impaired left ventricular function over time. Despite growing attention to ACS in young adults in India, there is limited data, with only a few hospital-based studies addressing this issue specifically within this demographic [9]. As a result, young adults with ACS remain underreported and underrecognized in the medical community. Early identification of risk factors, a deeper understanding of pathophysiology, and the development of targeted prevention strategies are essential to improving outcomes. This study aims to assess the clinical characteristics, associated risk factors, and angiographic profiles of young adults presenting with ACS at a tertiary care hospital in South India.

Materials and Methods

Study Design and Population:

This retrospective observational study was conducted at a tertiary care hospital in South India over a span of 2 years and 2 months (January 2023 to February 2025). During this period, a total of 4070 coronary interventions were performed. Among these, 402 patients aged 18 to 45 years who underwent coronary angiography (CAG) for ACS were included in the study. The hospital primarily serves patients from low- and middle-income backgrounds, providing a unique opportunity to evaluate the burden of ACS in a resource-limited setting.

Inclusion Criteria:

1. **Age**: Patients aged 18 to 45 years.
2. **Condition**: Patients who underwent coronary angiography (CAG) for Acute Coronary Syndrome (ACS) during the study period (January 2023 to February 2025).
3. **Hospital Setting**: Patients treated at a tertiary care hospital in South India.
4. **Coronary Intervention**: Patients who received coronary intervention as part of their ACS management.
5. **Study Population**: A total of 402 patients who underwent coronary angiography for ACS during the study period.
6. **Informed Consent**: Patients who consented to participate in the study or whose data was available for analysis according to ethical guidelines.

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Exclusion Criteria:

1. **Age**: Patients outside the age range of 18 to 45 years.
2. **Non-ACS**: Patients undergoing coronary angiography for reasons other than Acute Coronary Syndrome (e.g., elective angiography, non-ACS indications).
3. **Incomplete Data**: Patients with incomplete clinical data or missing records.
4. **Pregnancy**: Pregnant or breastfeeding women.
5. **Other Severe Comorbidities**: Patients with severe comorbidities (e.g., terminal illness, advanced cancer) that may affect the interpretation of study outcomes.
6. **Refusal to Participate**: Patients who refused to participate in the study or whose data could not be accessed due to legal or ethical constraints.

Data Collection and Analysis

Data were retrospectively collected from the hospital's electronic medical records, including demographic details, clinical presentation, medical history, risk factors, laboratory findings, angiographic results, and treatment interventions. Key variables included:

- **Demographics**: Age, gender, socioeconomic status.
- **Symptoms**: Chest pain, dyspnea, palpitations, etc.
- **Medical History**: Hypertension, diabetes, smoking, alcohol use.
- **Cardiovascular Risk Factors**: Dyslipidemia, obesity, family history.
- **Electrocardiographic Diagnosis**: Unstable angina, non-ST elevation MI (NSTEMI), ST elevation MI (STEMI).
- **Angiographic Findings**: Extent of coronary involvement, vessel disease pattern.
- **Management Strategies**: Medications, revascularization procedures.

Primary Outcome Measures:

- Prevalence and distribution of conventional and modifiable risk factors.
- Extent of coronary artery involvement.
- Success rates of revascularization procedures.
- Associations between risk factors and angiographic profiles.

Risk Factor Analysis:

- **Hypertension (HTN)**: Defined as an average blood pressure ≥ 130/80 mmHg or use of antihypertensive medication [10].
- **Diabetes Mellitus (DM)**: Defined by a random blood glucose ≥ 200 mg/dL, HbA1c ≥ 6.5%, or use of antidiabetic medication [11].
- **Smoking**: Defined as daily tobacco use or any smoking within one month of the index event [12].
- **Obesity**: Categorized based on South Asian BMI cut-offs: <18.5 kg/m² (underweight), 18.5–22.9 kg/m² (normal), 23.0–24.9 kg/m² (overweight), ≥ 25.0 kg/m² (obese) [13].
- **Family History**: Considered positive if a primary male or female relative was diagnosed with CAD before the age of 55 or 65 years, respectively [14].

Statistical Analysis

Data analysis was performed using SPSS software (version 25). Continuous variables were expressed as means and standard deviations, while categorical variables were presented as percentages. Chi-square tests and independent t-tests were used to examine associations between categorical and continuous variables, respectively. A p-value of < 0.05 was considered statistically significant.

Results

Patient Demographics and Clinical Characteristics

- A total of 402 young patients (aged <45 years) with acute coronary syndrome (ACS) were included in the study. Mean of the population was 39.88± 4.96 years.
- Gender distribution: The majority of patients were male (79.4%), with females accounting for 20.6%.
- Age distribution: The highest proportion of ACS cases (56.7%) occurred in the 41–45 years age group. Only 1.5% of cases were observed in patients under 25 years.

Presenting Symptoms:

- Chest pain was the most common symptom, reported in 92% of cases.
- Dyspnoea (36%), palpitations (24.8%), and syncope (10%) were also observed.
- Males were more likely to present with chest pain (74.6%), while females more commonly reported dyspnoea (10%) and epigastric pain (12.4%). Baseline characteristics of the population are summarized in Table 1.

Cardiovascular Risk Factors:

- Smoking (80.1%) and dyslipidemia (77.6%) were the most prevalent risk factors. Diabetes mellitus (57.2%) and hypertension (43%) were also common.
- Alcohol consumption (64.2%) was more common among males, while a family history of coronary artery disease was observed in 10.4% of patients.
- The majority of patients (81.1%) had at least one cardiovascular risk factor, with 12.4% presenting four or more risk factors, indicating a significant burden of comorbidities. Table 2 summarizes the distribution of cardiovascular risk factors

Table 01: Patient characteristics of the population

S. No	Patient characteristic	Observation	Male	Female
1	Age	39.88± 4.96 years		
2	Sex		319 (79.4%)	83 (20.6 %)
3	Age groups	402	319 (79.4%)	83 (20.6 %)
	18-25 years	6 (1.5%)	5 (1.3%)	1(0.2%)
	26-30 years	15 (3.7%)	14 (3.4%)	1(0.2%)
	31-35 years	47 (11.7%)	40 (10%)	7 (1.7%)
	36-40 years	106 (26.4%)	89 (22.1%)	17 (4.2%)
	41-45 years	228 (56.7%)	171 (42.5%)	57 (14.2%)
4	Symptoms			
	Chest pain	370 (92%)	300 (74.6%)	70 (17.4%)
	Dyspnoea	145 (36%)	105 (26.1%)	40 (10%)
	Palpitations	100 (24.8%)	69 (17.1%)	31 (7.7%)
	Syncope	40 (10%)	24 (6%)	16 (4%)
	SOB	170 (42.3%)	120 (29.8 %)	50 (12.4%)
	Epigastric pain	20 (5%)	14 (3.5%)	6 (1.5%)
5	ECG diagnosis			
	NSTEMI	104 (25.8%)	70 (17.4 %)	34 (8.4%)
	STEMI	143 (35.6%)	124 (30.8%)	19 (4.8%)
	Unstable angina	155 (38.6%)	125 (31.1%)	30 (7.5%)

Table 02: The distribution of the cardiovascular risk factors

S. No	Angiographic profile	Observation (n, %)	Male (n, %)	Female (n, %)
1	Smoking	322 (80.1%)	306 (76.1%)	16 (4%)
2	Alcohol consumption	258 (64.2%)	238 (59.2%)	20 (5%)
3	Dyslipidaemia	312 (77.6%)	251 (62.4%)	61 (15.2%)
4	Diabetes mellitus	230 (57.2%)	184 (45.7%)	46 (11.5%)
5	Hypertension	282 (70.1%)	232 (57.7%)	50 (12.4%)
6	Obesity	173 (43%)	122 (30.3%)	51 (12.7%)
7	Family history of coronary artery disease (CAD)	42 (10.4%)	31 (7.7%)	11 (2.7%)
8	Number of risk factors			
	None	76 (18.9%)	65 (16.1%)	11 (2.8%)
	One	210 (52.2%W)	195(48.5%)	25 (3.7%)
	Two	59 (14.7%)	40 (9.9%)	19 (4.8%)
	Three	37 (9.2%)	23 (5.7%)	14 (3.5%)
	Four	14 (3.4%)	11 (2.7%)	3 (0.7%)
	Five	6 (1.5%)	4 (1.0%)	2 (0.5%)

Table 03: The coronary angiographic profile of the study participants

S. No	Angiographic profile	Observation (n, %)	Male (n, %)	Female (n, %)
1	Coronary artery involved			
	LAD	191 (47.5%)	170(42.3%)	21(5.2%)
	RCA	111 (27.6%)	92 (22.8%)	19(4.8%)
	LCX	83 (20.6%)	67 (16.7%)	16(3.9%)
2	Single vessel disease (SVD)	194 (48.3%)	172 (42.8%)	22 (5.5%)
	RCA only	52 (12.9%)	42 (10.4%)	10 (2.5%)
	LAD only	122 (30.3%)	113 (28.1%)	09 (2.2%)
	LCX only	20 (5%)	17 (4.2%)	03 (0.8%)
3	Double vessel disease (DVD)	52 (12.9 %)	38 (9.4%)	14 (3.5%)
	RCA, LAD	18 (4.5%)	15 (3.7%)	3 (0.8%)
	LAD, LCX	22 (5.5%)	15 (3.7%)	7 (1.8%)
	RCA, LCX	12 (3%)	8 (2%)	4 (1%)
4	Triple vessel disease (TVD)	29 (7.2%)	27 (6.7%)	2 (0.5%)
5	Normal coronaries	127 (31.6%)	82 (20.4%)	45 (11.2%)

Angiographic Profile:

- Single-Vessel Disease (SVD) was the most common finding (48.3%), with the left anterior descending (LAD) artery (30.3%) being the most frequently affected.
- Double-Vessel Disease (DVD) was present in 12.9% of cases, with involvement of the LAD and left circumflex artery (LCX) in 5.5%.
- Triple-Vessel Disease (TVD) was observed in 7.2% of patients, indicating more extensive coronary pathology.
- Normal coronary arteries were found in 31.6% of patients, more frequently in females (11.2%) than in males (20.4%), suggesting alternative mechanisms for ACS, such as vasospasm or microvascular disease. Table 3 summarizes the coronary angiographic profile of the study participants.

Age-wise Distribution of Coronary Artery Disease (CAD):

The prevalence of significant CAD increased with age, with the highest burden (56.7%) observed in the 41-45 years age group. The age-wise distribution of the CAD is shown in Figure 01.

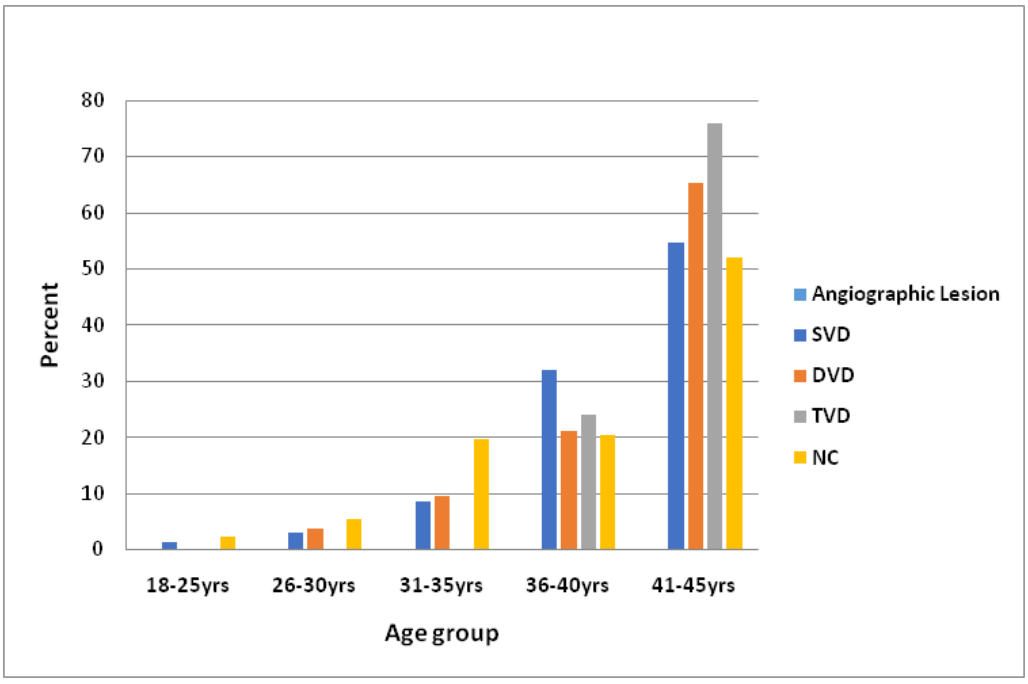

Figure 01: Distribution of CAD as per the age group.

- LAD involvement was the most common (47.5%), followed by the right coronary artery (RCA) (27.6%) and left circumflex (LCX) (20.6%).
- Multivessel disease (DVD and TVD) was more prevalent in older patients (41-45 years), highlighting the role of progressive atherosclerosis with aging.

Discussion

Coronary artery disease (CAD) remains the leading cause of morbidity and mortality globally, with its pathogenesis linked to a complex interplay of both established and emerging risk factors, even among younger populations. In India, CAD prevalence is notably higher in the younger demographic, driven by changing lifestyle factors. Compared to Western populations, CAD manifests earlier in India, with the INTERHEART study indicating a 10-year earlier onset in South Asians [15]. Our study corroborates these findings, with most cases presenting in individuals over 41 years, emphasizing the urgent need for early prevention strategies in this age group.

Gender Distribution and Demographic Trends:

Consistent with previous studies, our study showed a male predominance (79.4%) among young ACS patients who reported that 88-92% of young MI patients were male [5]. The protective role of estrogen in premenopausal women helps explain the lower CAD incidence in this group, although postmenopausal women face a marked increase in risk, underscoring the need for vigilant monitoring and aggressive risk management [16]. However, with the rising prevalence of metabolic syndrome, smoking, and diabetes among young women, it is essential to closely monitor evolving gender-specific risk patterns.

Clinical Presentation and Symptoms:

Classic chest pain was the most common symptom (92%), as expected, but atypical symptoms like dyspnoea (36%), shortness of breath (42%), and palpitations (25%) were also prevalent, reflecting the diverse clinical spectrum of CAD. Women, in particular, had a lower incidence of classic chest pain and higher rates of atypical symptoms, such as epigastric discomfort and dyspnoea, which are often overlooked. This gender-specific symptomatology highlights the importance of clinical vigilance, as delayed diagnoses of atypical presentations can lead to worsened outcomes. Among clinical syndromes, unstable angina was most common (38.6%), followed by STEMI (35.6%) and NSTEMI (25.8%), suggesting many patients present late, often requiring emergent intervention.

Cardiovascular Risk Factors and T2DM Prevalence:

A key finding in our study was the high prevalence of T2DM (52.2%) which reflect India's higher diabetes burden, with insulin resistance and genetic predisposition contributing to a higher incidence of diabetes-related cardiovascular disease. Diabetes accelerates atherosclerosis through chronic inflammation, endothelial dysfunction, and platelet aggregation, raising the risk of ACS at younger ages. Additionally, 80.1% of our cohort were active smokers, reinforcing the strong association between smoking and premature ACS [17]. The clustering of metabolic risk factors, such as obesity and sedentary behavior, further emphasizes the need for early cardiovascular screening.

Our study identified several prevalent risk factors, including smoking (80.1%), dyslipidemia (77.6%), hypertension (70.1%), and diabetes mellitus (52.2%). These findings align with other Indian cohorts, which highlighted high smoking rates, obesity, and physical inactivity in young CAD patients [17,18]. Risk stratification revealed that 52.2% of patients had at least one risk factor, 14.7% had two, and 9.2% had three. Interestingly, 18.9% had no identifiable conventional risk factors, suggesting the involvement of non-traditional factors such as psychological stress, genetics, dietary factors, and emerging biomarkers like lipoprotein(a) and homocysteine [3,19], [20-22].

Angiographic Profile and Disease Severity

In our cohort, single-vessel disease (SVD) was the most common (48.3%), with the left anterior descending artery (LAD) being the most frequently affected vessel. This finding is consistent with studies suggesting that young ACS patients typically have less extensive coronary involvement compared to older patients [23,9]. The high frequency of LAD involvement points to its vulnerability to early-onset atherosclerosis, necessitating early intervention and aggressive lipid management. Notably, 31.6% of patients had normal coronary angiograms, suggesting alternative mechanisms such as coronary artery spasm, microvascular dysfunction, or spontaneous coronary artery dissection (SCAD). The prevalence of normal angiograms was higher in females, aligning with findings that non-atherosclerotic causes of MI are more common in younger women.

Coronary angiography revealed LAD involvement in 48%, followed by right coronary artery (RCA) in 27.6%, and left circumflex artery (LCx) in 20.6%. The high prevalence of SVD suggests that early interventions, including percutaneous coronary intervention (PCI) or aggressive medical management, may prevent progression to more complex multivessel disease. These findings align with studies by Kumbhalkar et al. [23] and Suri et al. [9], which also reported high LAD involvement (82.5% and 77%) and SVD prevalence (57.1% and 69.5%). Lifestyle factors such as obesity, diabetes, and alcohol consumption were associated with higher rates of triple-vessel disease (TVD), reinforcing the impact of lifestyle on disease severity [24].

BMI and Long-Term Cardiovascular Risk

Our study further supports the growing recognition that obesity is a key determinant of premature CAD. Studies, including Myint et al. [25], have highlighted that a higher BMI is associated with increased cardiovascular mortality. The combined effects of obesity, insulin resistance, and dyslipidemia underline the need for targeted weight management strategies to mitigate early-onset ACS risk.

Clinical Outcomes and Long-Term Prognosis:

The study demonstrated favorable in-hospital outcomes, with no mortality and a lower complication rate, aligning with global literature that suggests young ACS patients generally have better short-term prognoses. However, long-term studies indicate that young MI survivors remain at higher risk for recurrent cardiovascular events, reduced ejection fraction, and peripheral vascular disease. This emphasizes the need for long-term follow-up, aggressive risk factor modification, and adherence to secondary prevention strategies.

Implications for Clinical Practice and Public Health:

Our findings have several important clinical and public health implications:

Early Risk Stratification: Targeted screening initiatives for early identification of high-risk individuals are critical, particularly in younger populations.

Gender-Specific Interventions: The atypical presentation in women, along with their higher likelihood of presenting with late-stage disease, calls for gender-sensitive diagnostic and therapeutic protocols.

Aggressive Smoking Cessation: Given the high prevalence of smoking in our cohort, tobacco cessation programs should be prioritized, with integrated pharmacologic and behavioral interventions.

Optimized Medical Therapy: For patients with SVD and high-risk profiles, aggressive medical management, particularly with guideline-directed therapies, is essential to mitigate the risk of disease progression.

Study Limitations

Retrospective design: As a record-based study, certain variables, such as lifestyle factors, medication adherence, and long-term outcomes, could not be assessed.

Lack of a control group: A comparative analysis with a non-ACS population would have provided a better understanding of specific risk factor contributions.

Long-term follow-up data unavailable: While short-term outcomes were favorable, further research is needed to determine the long-term cardiovascular prognosis of young ACS patients.

The observation that nearly one-third of the patients had normal coronary angiograms indicates the need for further exploration into alternative mechanisms of non-atherosclerotic myocardial infarction, such as coronary vasospasm, SCAD, or hypercoagulability in young individuals.

Conclusion

Our study highlights the high prevalence of smoking, hypertension, dyslipidemia, and T2DM as key contributors to premature ACS in young adults. The predominance of LAD involvement, the relatively higher rate of normal coronary angiograms in females, and the clustering of metabolic risk factors emphasize the need for early screening, lifestyle interventions, and aggressive risk factor modification. While short-term outcomes are favorable, the long-term cardiovascular risk remains significant, necessitating continued surveillance and preventive strategies. Further research is warranted to explore the pathophysiological differences in young ACS patients, particularly regarding non-atherosclerotic mechanisms of MI in females.

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None

Future Directions:

Implementation of public health policies aimed at reducing smoking and other modifiable risk factors.

Further multicentric studies to provide a more comprehensive understanding of the epidemiology of ACS in younger populations across India.

Development of region-specific guidelines addressing the unique risk factors of the South Asian population.

Consent to publish:

Written and informed consent for publication of this case report was obtained from the parents of the patient**.**

Competing interests:

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