Assessment of Hematological Profiles in Children Treated Under General Anesthesia for ECC - A Cross-Sectional Study

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ABSTRACT

Background: Early Childhood Caries (ECC) remains a global public health concern linked to systemic factors including hematological profiles, influencing immune and nutritional status.

Aim: To assess hematological and biochemical parameters in children treated under general anesthesia (GA) for ECC and evaluate age-related correlations.

Materials and Methods: A cross-sectional study was conducted on 479 children aged 1–6 years undergoing dental treatment under GA for ECC. Parameters recorded included hemoglobin, leukocyte differentials, platelet count, ESR, clotting and bleeding time, and blood glucose. Correlation analysis was performed using Pearson's test.

Results: Neutrophils ($r = 0.21$, $p = 0.0001$), hemoglobin ($r = 0.12$, $p = 0.0088$), random blood sugar ($r = 0.11$, $p = 0.014$), platelet count ($r = 0.086$, $p = 0.041$), monocytes ($r = 0.12$, $p = 0.0502$), and clotting time ($r = 0.067$, $p = 0.033$) showed a significant positive correlation with age. Eosinophils ($r = -0.14$, $p = 0.0001$) and basophils ($r = -0.15$, $p = 0.0001$) decreased with age. Total WBC count, ESR, and RBC count showed no significant correlation ($p > 0.05$). Most parameters remained within pediatric reference ranges.

Conclusion: Significant correlations between hematological parameters and age in children with ECC highlight the role of systemic health monitoring in pediatric dental care to enhance ECC prevention and management strategies.

Keywords: Early Childhood Caries; Pediatric Dentistry; General Anesthesia; Child, Preschool, Good Health and Well-Being.

INTRODUCTION

Early Childhood Caries (ECC) is a common and rapidly progressing form of dental decay seen in children under the age of six. Its consequences extend beyond oral discomfort, often leading to eating difficulties, impaired speech, infections, and a decline in overall well-being.[1] The condition is driven by a mix of behavioral, dietary, and environmental factors such as poor oral hygiene practices, frequent intake of sugary foods, low parental awareness, and emerging systemic factors including hematological status and immunity.[2],[3]

According to the World Health Organization, between 60% and 90% of school-aged children globally are affected by dental caries, with ECC forming a major part of this burden, especially in low- and middle-income regions.[4],[5] In India, a systematic review reported ECC prevalence at approximately 49.6% among children under six, with regional variations: Andhra Pradesh (63%), Tamil Nadu (55.7%), Assam (43.4%), and Sikkim (41.9%).[6] A population-based study in Salem, Tamil Nadu, found that 16% of children aged 18–72 months were affected by ECC, particularly among working-parent households and lower-income families.[7] Post-pandemic data further indicate a consistent ECC burden with a higher incidence among 3–4-year-olds, compounded by reduced treatment compliance and healthcare access during COVID-19, underscoring the need for enhanced parental education and public health measures.[8],[9],[10].

While behavioral and dietary factors are well-established contributors, recent research emphasizes systemic influences such as malnutrition and anemia on ECC development.[11],[12] In India, 58.6% of children under five years are anemic, and iron deficiency anemia (IDA) can weaken immune responses, alter salivary quality, and contribute to enamel defects, facilitating bacterial colonization and caries formation.[13] Studies have shown that reduced iron levels impair saliva's protective properties against Streptococcus mutans, increasing ECC risk.[14]

Other hematological parameters, including hemoglobin levels, white blood cell counts, and platelet counts, are increasingly recognized as indicators of oral health status. Anemic children often exhibit delayed healing and higher susceptibility to oral infections, while inflammatory markers like C-reactive protein (CRP) may indicate systemic inflammatory burdens influencing oral tissues. ECC has been linked to an increased risk of respiratory infections, demonstrating broader systemic implications.[15]

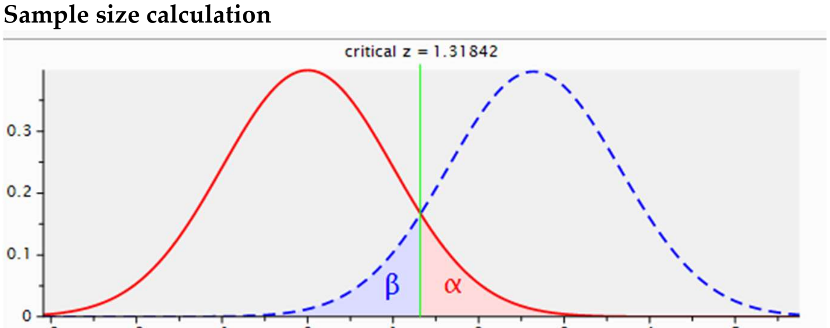
Despite this emerging evidence, no prior studies in India have systematically evaluated hematological profiles in children with ECC undergoing treatment under general anesthesia, representing a critical research gap. Given this multifactorial background, analyzing hematological parameters in children receiving dental rehabilitation under general anesthesia may provide deeper insights into the systemic factors contributing to ECC and aid in developing integrated pediatric preventive strategies.

MATERIALS AND METHODS

Study design and study setting

A cross-sectional study was conducted among children aged 1 to 6 years at a private hospital in Chennai to collect hematological data from the Departments of Pediatric Dentistry and Anaesthesiology, Saveetha Dental College, Chennai, India. Data were obtained from children undergoing dental procedures under general anesthesia (GA) specifically for the treatment of Early Childhood Caries (ECC). The study protocol was reviewed and approved by the Institutional Review Board, and ethical clearance was obtained (IHEC/SDC/UG-2162/24/PEDO/109).

Sample size calculation



A power analysis using a z-test (tetrachoric model) was conducted to assess the association between ECC and hematological parameters in children. With a sample size of 479, assumed effect size (ϱ = 0.1), and a one-tailed test, the study achieved a high power of 90.6%. The α and β error probabilities were both 9.37%, indicating a balanced risk of false positives and negatives. This confirms that the study is adequately powered to detect a small but significant correlation between ECC and blood parameters.

Study Duration

The study was conducted over a period of one year, from June 2024 to June 2025.

Ethical Approval and Informed Consent

The purpose and methodology of the study were submitted to the Institutional Review Board, and ethical clearance was obtained (IHEC/SDC/UG-2162/24/PEDO/109). Informed written consent was obtained from the parents or legal guardians of all participating children.

Inclusion Criteria

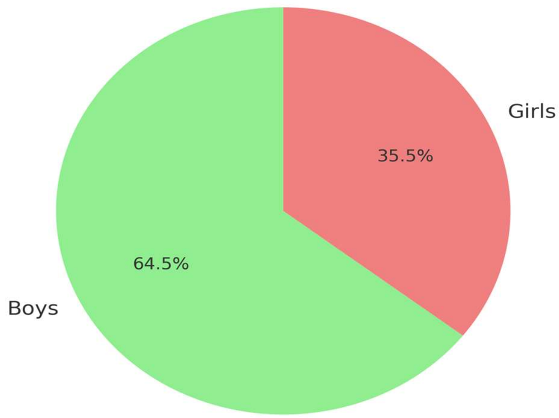
1. Children aged between 1 and 6 years.
2. Children scheduled for FMR dental procedure under general anesthesia (GA) specifically due to Early Childhood Caries (ECC).
3. Children whose parents or guardians provided informed consent for participation.
4. Children who have received antibiotic coverage (e.g., amoxicillin or metronidazole) within the past 3 months.
5. Children who had acute infections, swelling, or fever on the day of surgery.
6. Children without a history of frequent episodes of fever in the past 6 months

Exclusion Criteria

1. Children scheduled for dental procedures unrelated to ECC under general anaesthesia.
2. Children with a history of blood transfusion within the past 6 months.
3. Children with known hematological disorders, immunocompromised conditions, congenital cardiac disease, or chronic respiratory illness.

RESULTS

The study examined how age influences blood and biochemical markers in 479 young children undergoing dental treatment under general anesthesia. Most were preschoolers, with more boys than girls. Key findings showed that neutrophils, monocytes, hemoglobin, platelet count, clotting time, and blood sugar levels increased slightly with age, reflecting normal growth and immune development. Meanwhile, eosinophils and basophils decreased with age, and other parameters like RBC, WBC, ESR, and lymphocytes remained largely unchanged. This highlights selective, age-linked variations in children's blood profiles.



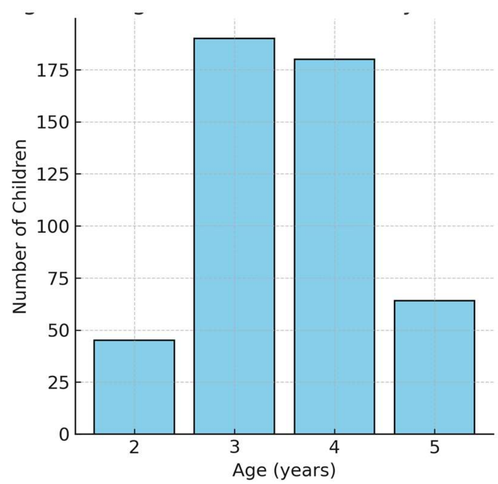


Figure 1a (left): shows age distribution and Figure 1b (right): gender wise distribution of study participants

Figure 1a illustrates the age distribution of the 479 study participants. The majority of the children were between 3 and 4 years old, aligning closely with the overall mean age of 3.35 ± 0.78 years. This suggests that the study predominantly included preschool-aged children, which is relevant considering the developmental and immunological characteristics of this age group. Figure 1b shows the gender distribution, indicating that boys comprised a larger portion of the sample (64.5%) compared to girls (35.5%). This male predominance could reflect demographic trends in healthcare utilization or sampling variation.

Parameter	**n**	**Mean ± SD**	**Normal Pediatric Range**
Hemoglobin (g/dL)	479	11.07 ± 1.37	11.5 – 13.5 g/dL
Random Blood Sugar (mg/dL)	479	88.27 ± 12.38	70 – 140 mg/dL
Bleeding Time (sec)	479	134.33 ± 29.18	90 – 180 sec
Clotting Time (sec)	479	515.35 ± 78.99	400 – 700 sec
Total Leukocyte Count (cells/cu mm)	479	9560.85 ± 2780.66	5,000 – 14,000/cu mm
Neutrophils (%)	479	55.34 ± 11.55	30 – 60%
Lymphocytes (%)	479	47.62 ± 12.20	40 – 70%
Monocytes (%)	479	3.82 ± 2.87	2 – 8%
ESR (mm/hr)	479	27.78 ± 4.03	< 20 mm/hr
Platelet Count ($\times 10^5$/cu mm)	479	3.84 ± 1.66	1.5 – 4.5 $\times 10^5$/cu mm
RBC Count (million/cu mm)	479	5.15 ± 3.93	4.1 – 5.5 million/cu mm
Age (years)	479	3.35 ± 0.78	—

Table 1: Descriptive Statistics of Hematological and Biochemical Parameters Among Study Participants (= 479)

Table 1 presents the descriptive statistics of hematological and biochemical parameters among 479 children with a mean age of 3.35 ± 0.78 years. The mean hemoglobin level was 11.07 ± 1.37 g/dL, slightly lower than the typical pediatric range, suggesting possible mild anemia in some children. Random blood sugar (88.27 ± 12.38

mg/dL) was within normal limits, indicating stable glucose metabolism. Bleeding time (134.33 ± 29.18 sec) and clotting time (515.35 ± 78.99 sec) were within expected ranges, reflecting normal platelet function and coagulation activity. The total white blood cell count (9560.85 ± 2780.66 cells/cu mm) was also within the standard pediatric range, supporting a healthy immune profile. Neutrophils (55.34 ± 11.55%) were slightly elevated, possibly indicating an immune response, while lymphocytes (47.62 ± 12.20%) and monocytes (3.82 ± 2.87%) remained within normal limits. ESR (27.78 ± 4.03 mm/hr) was mildly elevated, suggesting subclinical inflammation or minor infections in some participants. The platelet count (3.84 ± 1.66 $\times 10^5$/cu mm) was within the normal range, ensuring proper clotting potential, and the red blood cell count (5.15 ± 3.93 million/cu mm) had a normal mean with a wide standard deviation, indicating variability among individuals. Overall, the data suggest that most children had hematological parameters within or near normal limits, with minor variations possibly due to individual health or nutritional differences.

S. No.	Parameter	r-value	p-value
1	Neutrophil %	0.21	0.0001
2	Eosinophil %	-0.14	0.0001
3	Basophil %	-0.15	0.0001
4	Total WBC Count	0.016	0.74
5	Clotting Time	0.067	0.033
6	Bleeding Time	0.04	0.36
7	Random Blood Sugar (RBS)	0.11	0.014
8	Hemoglobin	0.12	0.0088
9	Platelet Count	0.086	0.041
10	ESR	0.053	0.47
11	Monocyte %	0.12	0.0502
12	Lymphocyte %	-0.081	0.051

Table 1: Correlation Between Age and Hematological Parameters

Table 1 presents the correlation between age and various hematological parameters in children treated under general anesthesia for early childhood caries. A weak but statistically significant positive correlation was observed between age and several parameters, including neutrophil percentage (r = 0.21, p = 0.0001), hemoglobin (r = 0.12, p = 0.0088), random blood sugar (r = 0.11, p = 0.014), platelet count (r = 0.086, p = 0.041), monocyte percentage (r = 0.12, p = 0.0502), and clotting time (r = 0.067, p = 0.033). These findings suggest a mild increase in these values with age, likely reflecting normal physiological and immunological development in growing children. In contrast, eosinophil (r = -0.14, p = 0.0001) and basophil percentages (r = -0.15, p = 0.0001) showed a weak but significant negative correlation, indicating a slight decline with age, consistent with reduced allergic or inflammatory responses. Lymphocyte percentage (r = -0.081, p = 0.051) also decreased slightly with age but was just outside the threshold for statistical significance. Meanwhile, total WBC count, ESR, and bleeding time exhibited no significant correlation with age, suggesting these parameters remain relatively stable in this pediatric cohort.

Figure 2 illustrates the pearson correlation between age and selected hematological parameters: clotting time, bleeding time, random blood sugar (RBS), and hemoglobin levels. A weak but statistically significant positive correlation was observed between age and clotting time (r = 0.067, p = 0.033), indicating that as children grow older, their clotting time tends to slightly increase, though the strength of the association remains minimal. Similarly, RBS showed a weak positive correlation with age (r = 0.11, p = 0.014), suggesting a mild age-related increase in blood glucose levels, potentially due to metabolic maturation. Hemoglobin levels also demonstrated a weak but significant positive correlation (r = 0.12, p = 0.0088), implying that older children

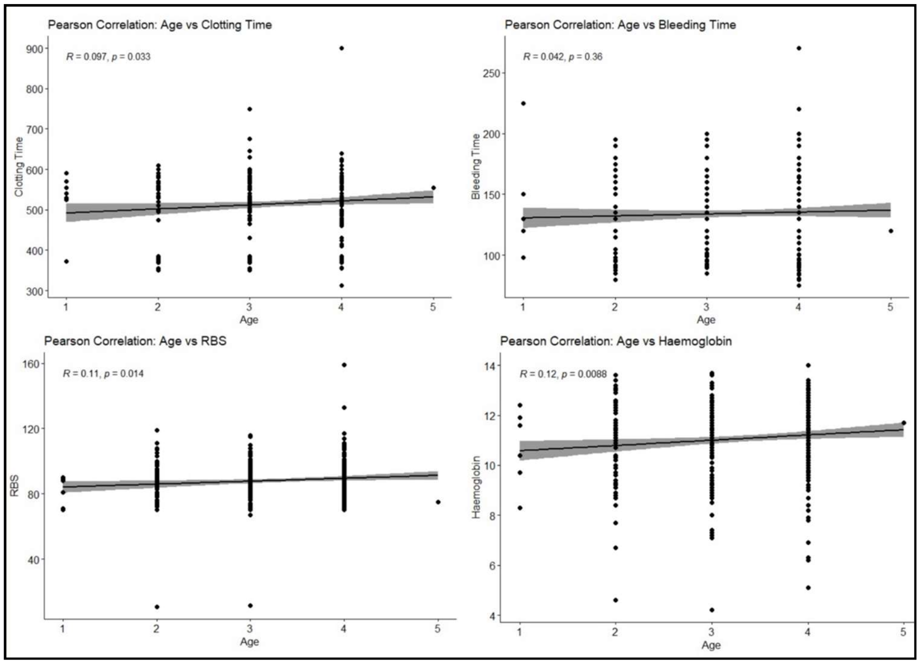


Fig2.Graphical representation of Pearson correlation between age and clotting time, bleeding time, RBS and hemoglobin

generally exhibit higher hemoglobin levels, consistent with normal hematological development. In contrast, bleeding time had a very weak and statistically non-significant correlation with age (r = 0.040, p = 0.36), indicating no meaningful association. These findings underscore subtle, age-related physiological changes in hematological parameters relevant for safe and effective pediatric dental care under general anesthesia.

Figure 3 illustrates the pearson correlation analysis between age and select hematological parameters such as platelet count, erythrocyte sedimentation rate (ESR), monocytes, and lymphocytes revealed varied outcomes. A non-significant and weak correlation was found between age and both platelet count (r = 0.038, p = 0.41) and ESR (r = 0.033, p = 0.47), indicating no meaningful age-related trends for these parameters. In contrast, a significant positive correlation was observed between age and monocyte levels (r = 0.12, p = 0.0092), suggesting that monocytes may gradually increase with age, potentially due to immune system development. However, the correlation between age and lymphocyte percentage (r = -0.086, p = 0.061) was not statistically significant, though it showed a weak declining trend. Regarding clotting-related and metabolic markers shown in Figure 2, clotting time displayed a weak but significant positive correlation (r = 0.067, p = 0.033), indicating that older children may have slightly longer clotting durations. Bleeding time, however, did not correlate significantly with age (r = 0.040, p = 0.36). For metabolic indicators, random blood sugar (RBS) showed a significantly weak positive correlation (r = 0.11, p = 0.014), and hemoglobin levels also increased slightly with age (r = 0.12, p = 0.0088), both pointing to age-related physiological changes. These findings collectively highlight that while some hematological parameters, like monocytes, RBS, and hemoglobin, increase with age, others such as platelets, ESR, bleeding time, and lymphocytes, remain largely unaffected.

Correlation analyses revealed mixed associations between age and additional hematological parameters, specifically red blood cell (RBC) count, total white blood cell (WBC) count, and neutrophil levels. A non-significant negative correlation was noted between age and RBC count (r = -0.083, p = 0.069), as well as between age and total WBC count (r = -0.045, p = 0.33), indicating that these parameters do not significantly change with age in this pediatric population. However, a statistically significant positive correlation was observed between age and neutrophil count (r = 0.1, p = 0.023), suggesting that neutrophil levels tend to rise slightly as children grow older. This finding reflects age-related maturation of the innate immune response. Overall, while RBC and total WBC counts remain stable, the increase in neutrophils with age highlights a selective effect of age on specific immune components, particularly the granulocytic lineage. These results emphasize that not all hematological parameters are equally influenced by age, underlining the importance of age-specific reference values in pediatric assessments (Fig 4).

DISCUSSION

Early Childhood Caries (ECC) remains a significant public health issue globally, with prevalence varying widely across regions and socioeconomic strata. Socioeconomic disparities play a pivotal role in ECC distribution, with children from disadvantaged backgrounds disproportionately affected.[16] Kassebaum et al. (2015) reported that ECC prevalence can reach up to 70% in low- and middle-income countries, whereas high-income nations report rates between 20% and 40%.[17] In this study, the overall prevalence of ECC in India was 49.6%, with Andhra Pradesh exhibiting the highest rates at 63% and Tamil Nadu following at 55.73%. This stark discrepancy underscores the urgent need for targeted interventions in high-prevalence regions, particularly those with socioeconomic vulnerabilities.

ECC is a multifactorial disease arising from the interaction between poor oral hygiene practices, high sugar intake, limited access to dental care, and systemic factors. Studies have shown that children from lower-income families are nearly twice as likely to suffer from ECC due to limited dental services and unhealthy dietary habits.[18],[15] Educational programs promoting optimal oral health practices from the eruption of the first tooth are essential in mitigating this burden. ECC has been associated with systemic health issues, especially respiratory conditions. Hwang et al. (2022) demonstrated that children with dental caries are at increased risk of respiratory infections due to the translocation of oral bacteria into the respiratory tract.[19],[20] These findings further support this association, proposing that inflammatory responses in ECC may impair immune defenses, increasing susceptibility to infections.

This study primarily explored the relationship between hematological parameters and ECC in a cohort of young children, revealing several notable associations. The mean age of the study participants was 3.35 years, aligning with the peak window for ECC development, as previously reported by Pereira et al. (2018).[21] A significant positive correlation was observed between age and hemoglobin levels, suggesting that hemoglobin concentrations tend to increase as children grow older. Khan et al. (2018) had similarly reported that improved nutritional status and enhanced erythropoiesis contribute to elevated hemoglobin levels with age.[22] Hemoglobin plays a crucial role in oxygen delivery to tissues, including the oral mucosa and dentition, which may enhance local immune responses. This could partially explain why older children demonstrate better oral health outcomes compared to younger ones, who may still be undergoing major nutritional and developmental changes.[23]

Another key finding was the positive correlation between age and neutrophil count. Neutrophils, a primary component of the innate immune response, play a critical role in combating bacterial infections, including those in the oral cavity. Gendron et al. (2008) described how neutrophils respond robustly to oral pathogens, especially *Streptococcus mutans*, a primary etiological agent of ECC.[24] The age-related increase in neutrophil count aligns with Jyonouchi et al, who reported enhanced immune competence with age.[25] This suggests that as neutrophil-mediated defenses mature, children become more capable of controlling cariogenic infections, thereby reducing ECC risk.

Conversely, no significant association was found between age and lymphocyte count in this study. Lymphocytes, crucial for adaptive immunity, have been previously implicated in ECC development.[26] However, the current study's findings imply that in early childhood, innate immune components such as neutrophils may have a more direct role in modulating oral bacterial challenges. Schulz et al. (2017) also noted that the adaptive immune system continues to evolve during early childhood, possibly explaining the lack of a significant correlation.[27],[28],[29]

The study also examined other hematological markers, including platelet count, erythrocyte sedimentation rate (ESR), and red blood cell (RBC) count. No significant correlation was observed between age and platelet count. Matsumoto et al. (2019) similarly reported no significant association between ESR and ECC, suggesting that ESR may not be a sensitive marker of localized oral inflammation in young children.[30] Although anemia has been proposed as a risk factor for ECC, no significant age-related trend was found in RBC counts in our study, contrasting with prior findings by Khan et al. (2018), which highlighted a link between anemia and increased caries susceptibility.

Iron deficiency anemia (IDA) remains a systemic factor implicated in ECC development. Children with IDA are more vulnerable to oral infections due to impaired immune responses. Harrison-Barry et al. (2022) emphasized that nutritional deficiencies, particularly iron deficiency, could alter salivary composition and weaken host defenses, thereby fostering an oral environment conducive to bacterial proliferation.[31] The observed increase in hemoglobin with age could reflect improved immune function, reducing ECC risk in older children.

This studyrevealed a significant positive correlation between age and random blood sugar (RBS) levels. Although this correlation was modest, it aligns with existing literature suggesting that dietary patterns, including sugar intake, significantly influence ECC development. Bennett et al. (2021) emphasized the role of high-sugar diets in promoting dental caries. Pereira et al. (2018) noted that children with higher glucose levels often consume sugary foods more frequently, increasing caries risk.[21] Elevated glucose levels may also impair immune function and support the growth of cariogenic bacteria, further compounding ECC risk

Limitations: This study employed a cross-sectional design, which restricts causal inferences. Longitudinal studies would provide deeper insight into the temporal dynamics between hematological changes and ECC development and did not account for other potential confounders such as dietary habits, oral hygiene practices, parental education, or frequency of dental visits, all of which can significantly influence ECC risk. Additionally, while hematological parameters were assessed, salivary biomarkers—which may offer more direct insights into oral immune status—were not evaluated. Lastly, although respiratory comorbidities were referenced, they were not directly assessed in this cohort, limiting conclusions on systemic outcomes.Future longitudinal and multicentric studies incorporating both hematological and salivary biomarkers, along with behavioral and socioeconomic factors, are warranted to better elucidate the relationship between systemic health and early childhood caries.

CONCLUSION

This study identified significant differences in selected hematological parameters among children with and without early childhood caries. Variations in hemoglobin levels, neutrophil counts, and blood glucose levels suggest a possible association between ECC and systemic health status. While these findings do not establish causality, they emphasize the importance of considering oral health within a broader health context. Further longitudinal studies are required to clarify the nature and clinical significance of these associations.

CONFLICT OF INTEREST

There is no conflict of interest.

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