International Journal of Contemporary Pediatrics
Balleda L et al. Int J Contemp Pediatr. 2025 Apr;12(4):609-614
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291
DOI: https://dx.doi.org/10.18203/2349-3291.ijcp20250766

Original Research Article

The utility value of SpO2/FiO2 (S/F) and PaO2/FiO2 (P/F) ratios for predicting initiation and efficiency of HFNC in children with respiratory distress admitted in PICU

Lokeswari Balleda*, Akhil Ijjada, Sravani Kolla, Chandra Sekhara Reddy Thimmapuram

Sri Ramachandra Children's and Dental Hospital, Old club Road, Gunturivari Thota, Kothapet, Guntur, Andra Pradesh, India

Received: 11 February 2025
Revised: 11 March 2025
Accepted: 15 March 2025

***Correspondence:**
Dr. Lokeswari Balleda,
E-mail: lballeda@gmail.com

ABSTRACT

Background: The PaO_2/FiO_2 (P/F) ratio, defined as the partial pressure of oxygen (PaO_2) divided by the fraction of inspired oxygen (FiO_2), and the SpO_2/FiO_2 (S/F) ratio, defined as pulse oximetric saturation (SpO_2) divided by FiO_2, are key indicators of oxygenation status. This study aimed to evaluate the utility of S/F and P/F ratios in predicting the initiation and effectiveness of HFNC in children with respiratory distress.
Methods: A prospective observational study of 133 children (1 month–14 years) with respiratory distress receiving HFNC was conducted. S/F and P/F ratios were measured at 0, 1, 12, and 24 hours after HFNC initiation. Outcomes assessed included ICU stay, hospital stay, and HFNC duration.
Results: Among 133 children (35.34% females, 64.66% males; mean age 0.9 years, weight 7.8 kg), 62.42% had moderate respiratory distress per P/F ratio, while 76.69% had mild respiratory failure per S/F ratio. Both ratios improved significantly over time ($p < 0.05$). A higher S/F ratio at initiation correlated with shorter ICU and hospital stays. The S/F ratio was a superior predictor of HFNC requirement (sensitivity: 85.29%, accuracy: 88.5%) compared to the P/F ratio (sensitivity: 41.91%, accuracy: 56.67%). ROC analysis confirmed strong predictive power for S/F (AUC 0.966).
Conclusion: The S/F ratio is a reliable, non-invasive surrogate for the P/F ratio in identifying respiratory distress and HFNC need, reducing the necessity for arterial blood sampling.

Keywords: Oxygen indices, Pulse oximetry, Arterial blood gas

INTRODUCTION

Acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) are grave syndromes associated with high mortality and morbidity.[1] Diagnostic criteria for ALI and ARDS includes acute onset of disease, chest radiograph demonstrating bilateral pulmonary infiltrates, lack of significant left ventricular dysfunction and Pao2/Fio2 (PF) ratio ≤300 for ALI or ≤200 for ARDS. (2) Daily arterial blood sampling to calculate the PF ratio is not feasible in most PICUs. Calculation of SF ratio may be a reliable non-invasive alternative to the PF ratio. And can be used as a surrogate for PF ratio to diagnose ARDS or ALI.[3]

Respiratory distress is a critical condition in pediatric patients, requiring prompt and effective intervention to improve oxygenation and reduce work of breathing. High-flow nasal cannula (HFNC) is a widely used non-invasive oxygen delivery method, offering a means of respiratory support for children in moderate to severe respiratory distress. Clinicians often face challenges in determining the right moment to initiate HFNC therapy and assess its efficiency. The SpO2/FiO2 (S/F) and

PaO2/FiO2 (P/F) ratios are two critical parameters that could be used to help guide clinical decisions regarding HFNC. "In our research, we investigated the utility of the S/F and P/F ratios and their impact on the initiation and effectiveness of HFNC therapy in children presenting with respiratory distress. Additionally, we classified these children based on their S/F and P/F ratios into mild, moderate, and severe respiratory distress categories."

Aims and objectives

This study aimed to determine the utility of the SpO2/FiO2 (S/F) and PaO2/FiO2 (P/F) as predictors of initiation and efficiency of HFNC in children admitted with respiratory distress

METHODS

Study type

This study was a prospective observational study.

Study duration

The study was conducted during January 2022 to October 2022, duration of the study was 10 months.

Study place

The study was conducted at Sri Ramachandra Children's and Dental Hospital, Guntur, Andhra Pradesh, India.

Inclusion criteria

Children aged 1 month to 14 years who were admitted to the PICU with respiratory distress of any etiology and received HFNC therapy were included in the study.

Exclusion criteria

Children younger than 1 month or older than 14 years, those with surgical or trauma-related conditions, and children with congenital abnormalities or cerebral palsy were excluded from the study.

Demographic data, vital parameters, S/F and P/F ratios, and outcome parameters were taken. Pao2 (arterial blood sampling), Spo2 (pulse oximetry) and Fio2 (set as per clinical condition) were charted. S/F and P/F ratios were calculated.

The S/F and P/F ratios were measured at 0, 1, 12, and 24 h after commencement of HFNC therapy. The first reading at "0" hour was taken at the time of admission, while the second reading at "1" hour was recorded approximately one hour after HFNC initiation. The third reading at "12" hours was taken around 12 hours after starting HFNC, and the fourth reading at "24" hours was part of routine daily monitoring to assess the child's condition. Outcomes such as the duration of ICU stay, hospital stay, and the number of days on HFNC were recorded.

Ethical consideration

This study was approved by Hospital ethics committee (SRCANDDH/EC/1/2021) and written informed consents were obtained from the parents before inclusion in the study.

Statistical analysis

The presentation of the categorical variables was done in the form of number and percentage (%). On the other hand, the quantitative data with normal distribution were presented as the means±SD and the data with non-normal distribution as median with 25th and 75th percentiles (interquartile range).

The comparison of the variables which were quantitative and not normally distributed in nature were analysed using Mann-Whitney Test.

The comparison of the variables which were qualitative in nature were analysed using Chi-Square test.

Spearman rank correlation coefficient was used for correlation of duration of ICU stay(days), hospital stay, oxygen requirement, HFNC requirement with P/F ratio, and S/F ratios. Receiver operating characteristic curve was used to find cut of point, sensitivity, specificity, positive predictive value and negative predictive value of P/F ratio, and S/F ratio for predicting HFNC requirement.

The data entry was done in the Microsoft EXCEL spreadsheet and the final analysis was done with the use of Statistical Package for Social Sciences (SPSS) software, IBM manufacturer, Chicago, USA, ver 25.0. For statistical significance, p value of less than 0.05 was considered statistically significant.

RESULTS

Demographic characteristics

Total children included were 133, of which female 35.34%, and male 64.66%. Mean age (in years) was 0.9 (0.3-3), and weight (in kg) was 7.8 (4.7-11.8) (Table 1).

Table 1: Demographic characteristics of HFNC.

Demographic characteristics	HFNC (n=133)
Gender	
Female	47 (35.34%)
Male	86 (64.66%)
Age (in years)	0.9 (0.3-3)
Weight (in kg)	7.8 (4.7-11.8)

§Mann Whitney test, † Chi square test

Table 2: Respiratory distress categorization according to PaO_2/FiO_2 (P/F) ratio at '0' hour i.e., at initiation of HFNC.

PaO_2/FiO_2 (P/F) ratio at '0' hour	HFNC (n=133)
Severe (<=100)	3 (2.26%)
Moderate (101-200)	83 (62.41%)
Mild (201-300)	30 (22.56%)
Normal (>300)	17 (12.78%)
Total	133 (100%)

Fisher's exact test

Table 3: Respiratory distress categorization according to SpO_2/FiO_2 (S/F) ratio at '0' hour i.e., at initiation of HFNC.

SpO_2/FiO_2 (S/F) ratio at '0' hour	HFNC (n=133)
Moderate (101-200)	13 (9.77%)
Mild (201-300)	102 (76.69%)
Normal (300)	18 (13.53%)
Total	133 (100%)

Fisher's exact test

Table 4: Correlation of duration of ICU stay(days), hospital stay, HFNC requirement with P/F ratio, and S/F ratio.

Variables	P/F ratio at 0 hour	S/F ratio at 0 hour
Duration of ICU (days)		
Correlation coef.	-0.043	-0.242
P value	0.626	0.005
Duration of hospital stay (days)		
Correlation coeff.	-0.114	-0.285
P value	0.193	0.001
Duration of HFNC requirement (days)		
Correlation coeff.	-0.126	-0.348
P value	0.150	<0.0001

Spearman rank correlation coefficient

Respiratory distress categorization according to PaO_2/FiO_2 (P/F) ratio at '0' hour i.e., at initiation of HFNC

In our study 83 children (62.42%) had P/F Ratio at '0' hour i.e., at the initiation of HFNC between 101-200 suggesting moderate respiratory distress. Followed by mild (201-300) in 30 children (22.56%), normal (>300) in 17 children (12.78%), and severe (<100) in 3 children (2.26%) respectively (Table 2).

Respiratory distress categorization according to SpO_2/FiO_2 (S/F) ratio at '0' hour i.e., at initiation of HFNC

In our study 102 children (76.69%) had S/F Ratio at '0' hour i.e., at the initiation of HFNC between 201-300 suggesting mild respiratory distress. Followed by normal (>300) in 18 children (13.53%), and moderate (101-200) in 13 children (9.77%) respectively (Table 3).

Table 5: Receiver operating characteristic curve of P/F ratio, S/F ratio for predicting HFNC requirement.

Variables	P/F ratio at 0 hour	S/F ratio at 0 hour
Area under the ROC curve (AUC)	0.601	0.966
Standard error	0.0399	0.0101
95% confidence interval	0.531 to 0.668	0.931 to 0.986
P value	0.0115	<0.0001
Cut off	≤155	≤303.3333
Sensitivity (95% CI)	41.91% (33.5 - 50.7%)	85.29% (78.2-90.8%)
Specificity (95% CI)	83.78% (73.4 - 91.3%)	95.95% (88.6 - 99.2%)
PPV (95% CI)	82.6% (71.6-90.7%)	97.5% (92.8 - 99.5%)
NPV (95% CI)	44% (35.6-52.6%)	78% (68.1-86.0%)
Diagnostic accuracy	56.67%	88.57%

Descriptive statistics of PaO_2/FiO_2(P/F) and SpO_2/FiO_2(S/F) ratio at '0' hour, '1' hour, '12' hours and at '24' hours.

Mean value of PaO2/FiO2 (P/F) ratio at '0' hour, '1' hour, '12' hours, '24' hours, was 196.52±90.03, 271.34±96.22, 286.2±93.5, 336.98±91.66 respectively. SpO2/FiO2 (S/F) ratio at '0' hour, '1' hour, '12' hours, '24' hours, was 251.81±40.62, 288.7±38.1, 308.93±33.12, 347.25±40.17 respectively.

Increasing trend was seen in PaO2/FiO2 ratio, and SpO2/FiO2 ratio with respect to time. Significant increase was seen in PaO2/FiO2 ratio, SpO2/FiO2 ratio at follow up as compared to baseline value. (p value< 0.05). (Figure 1 and Figure 2).

Correlation of duration of ICU stay(days), hospital stay, HFNC requirement with P/F ratio, and S/F ratio

Significant negative correlation was seen between duration of ICU stay (days), hospital stay(days), and duration of HFNC requirement (days) with S/F ratio at '0' hour with correlation coefficient of -0.242, -0.285, and -0.348 respectively. No correlation was seen between duration of ICU stay (days), hospital stay (days), and duration of HFNC requirement (days) with P/F ratio at '0' hour with correlation coefficient of -0.043, -0.114, and -0.126 respectively (Table 4).

These negative correlations mean that higher S/F ratios at "0" hour are associated with shorter ICU stays, hospital

stays, and shorter duration of HFNC requirement. Suggesting S/F ratio is a better predictor of ICU stay (days), hospital stay(days), and duration of HFNC requirement (days).

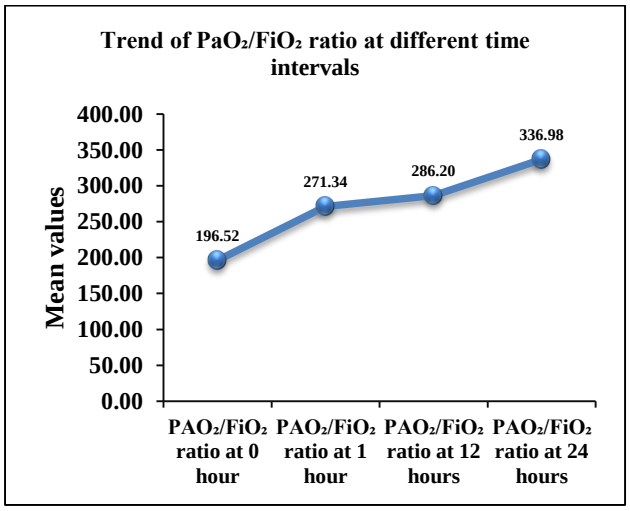

Figure 1: Descriptive statistics of PaO_2/FiO_2(P/F) ratio at '0' hour, '1' hour, '12' hours and at '24' hours.

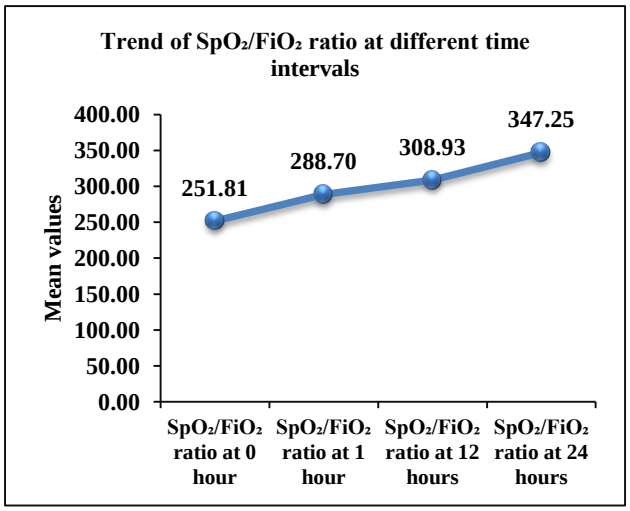

Figure 2: Descriptive statistics of SpO_2/FiO_2(S/F) ratio at '0' hour, '1' hour, '12' hours and at '24' hours.

Outcome distribution of HFNC group

All the study subjects were discharged (100%). Median (25th-75th percentile) of duration of ICU stay(days) was 4(3-5), and duration of hospital stay(days) was 6(5-7).

Receiver operating characteristic curve of P/F ratio, S/F ratio for predicting HFNC requirement

There is always a trade-off between sensitivity and specificity (any increase in sensitivity will be accompanied by a decrease in specificity). So, we choose that variable as best in which combination of sensitivity and specificity gives the maximum predictive value i.e. maximum area under curve.

In prediction of HFNC requirement S/F ratio at '0' hour had sensitivity of 85.29%, specificity of 95.95%, PPV of 97.5%, NPV of 78%, and diagnostic accuracy of 88.5%. In prediction of HFNC requirement P/F ratio at '0' hour had sensitivity of 41.91%, specificity of 83.78%, PPV of 82.6 %, NPV of 44%, and diagnostic accuracy of 56.67%. The S/F ratio is more effective than the P/F ratio for predicting the need for HFNC at "0" hour, based on its higher sensitivity, specificity, and overall diagnostic accuracy. The S/F ratio provides a more reliable prediction, with high accuracy (88.5%) and much better sensitivity (85.29%) compared to the P/F ratio (56.67% accuracy and 41.91% sensitivity).

Interpretation of the area under the ROC curve showed that the performance of S/F ratio at '0' hour (AUC 0.966; 95% CI: 0.931 to 0.986) was outstanding. Discriminatory power of P/F ratio at 0 hour (AUC 0.601; 95% CI: 0.531 to 0.668) was acceptable.

Among the two parameters, S/F ratio at '0' hour was the best predictor of HFNC requirement at cut off point of ≤303.3333 with area under curve of 0.966 for correctly predicting HFNC requirement (Table 5).

DISCUSSION

In our study total children included were 133, with Female 35.34%, and male 64.66%. Mean age (in years) was 0.9 (0.3-3), and weight (in kg) was 7.8 (4.7-11.8). In a study by Lohano PD et al, a total of 120 children were included, the mean age was 40.58±38.88 months and 67 (55.8%) were males. The mean FiO2 was 76.33%, the mean PaO2 and SpO2 were 100.35 mmHg and 94.37%, respectively.[4]

In our study significant negative correlation was seen between duration of ICU stay (days), hospital stay (days), and duration of HFNC requirement(days) with S/F ratio at '0' hour with correlation coefficient of -0.242, -0.285, and -0.348 respectively. Whereas no correlation was seen between duration of ICU stay (days), and non-significant mild negative correlation was seen between duration of hospital stay (days), and duration of HFNC requirement (days) with P/F ratio at '0' hour with correlation coefficient of -0.043, -0.114, and -0.126 respectively. The S/F ratio is more effective than the P/F ratio for predicting the need for HFNC at "0" hour, based on its higher sensitivity, specificity, and overall diagnostic accuracy. In their study by Colunga et al observed that SF ratio at '1' hour was a reliable predictor of early non-invasive ventilation failure in children having acute respiratory failure.[5] Lobete et al in their study validated the utility of SF ratio in critically ill children needing mechanical ventilation, non-invasive ventilation and oxygen support. And they observed a linear correlation between SF and PF ratio, rendering it a good replacement

of PF ratio.[6] Babu et al in their study showed a positive correlation of SF ratio and PF ratio with SF threshold values of 285 and 323 corresponding to PF values of 200 and 300 in any mode of oxygen supplementation. Hence, they concluded that the noninvasive SF ratio is a valuable surrogate to invasive PF ratio.[7]

In our study, in prediction of HFNC requirement S/F ratio at '0' hour had sensitivity of 85.29%, specificity of 95.95%, PPV of 97.5%, NPV of 78%, and diagnostic accuracy of 88.5%. Whereas P/F ratio at '0' hour had sensitivity of 41.91%, specificity of 83.78%, PPV of 82.6 %, NPV of 44%, and diagnostic accuracy of 56.67%. In our study interpretation of the area under the ROC curve showed that the performance of S/F ratio at '0' hour was outstanding, in predicting HFNC requirement with AUC 0.966; 95% CI: 0.931 to 0.986. In our study in predicting the HFNC requirement discriminatory power of P/F ratio at '0' hour was acceptable with AUC 0.601; 95% CI: 0.531 to 0.668.

In a study Beniwal et al, cut -offs of SF ratio < 300 and PF ratio <200 were able to determine the need PICU admission with a sensitivity of 97.30% and 62.16% respectively. The best cut-off of SF ratio for predicting PICU admission was <178.79 [AUC (95% CI) 0.841 (0.767, 0.914)], while that for PF ratio was <201.81 AUC (95% CI) of 0.849 (0.775, 0.924).[8] A similar study conducted by Khemani et al on the pediatric population reported that an S/F ratio cut-off of 201 could predict a P/F ratio consistent with ARDS with a sensitivity of 84% and specificity of 78%.

Additionally, an S/F ratio cut-off of 263 was found to predict Acute Lung Injury (ALI) with a sensitivity of 93% and specificity of 43%.[9] In contrast to our study, the study by Chang CC et al. reported that the most common indications for HFNC therapy were pneumonia (39.2%), sepsis-related respiratory distress (16.7%), and bronchiolitis (15.7%). The failure rate was 15.7% (16 of 102 children).

The initial S/F ratios were 211.87±39.85 in the success group and 165.64±46.49 in the failure group. Following disease progression, the lowest S/F ratios were 210.07±41.72 in the success group and 147.43±49.86 in the failure group. Early indicators of failure requiring escalation of respiratory support included higher initial and maximum FiO_2 levels and lower initial and lowest S/F ratios.[10]

In our study, among the parameters, S/F ratio at '0' hour was the best predictor of HFNC requirement at cut off point of ≤303.3333 with area under curve of 0.966 for correctly predicting HFNC requirement. A study by Kim GE, Choi SH, Park M, et al SF ratio was also found to predict high flow nasal canulation (HFNC) failure at initiation as well as 2 hours at cut-offs of <230 and <200, respectively.[11] In their study, Shaw N. et al. observed that the S/F ratio at admission had a sensitivity of 72% and specificity of 60%, while the P/F ratio demonstrated a sensitivity of 78% and specificity of 75% for predicting mortality. The area under the curve (AUC) for the S/F ratio was 0.82 (CI: 0.688–0.915). Furthermore, serial measurements of the S/F ratio were found to accurately predict mortality outcomes.[12]

Strengths of the study

Specifically targets children aged 1 month to 14 years, addressing a critical gap in research on oxygenation indices and HFNC outcomes in this demographic.

Non-invasive approach

Validates the S/F ratio as a non-invasive surrogate for the P/F ratio, reducing the need for arterial blood sampling, which is particularly beneficial in pediatric care.

Prospective study design

Employs a prospective observational design, ensuring real-time data collection and minimizing recall bias.

Comprehensive outcome analysis

Examines not only the predictive value of S/F and P/F ratios but also correlates these indices with clinical outcomes, including ICU stay, hospital stay, and HFNC duration.

High diagnostic accuracy

Demonstrates the superior diagnostic performance of the S/F ratio (sensitivity: 85.29%, diagnostic accuracy: 88.5%), with robust ROC analysis (AUC: 0.966).

Generates actionable insights

Provides practical recommendations for incorporating the S/F ratio into routine pediatric respiratory care.

CONCLUSION

The S/F ratio (SpO_2/FiO_2) is more effective at predicting the need for high-flow nasal cannula (HFNC) therapy, particularly at the initial hour ('0' hour). It has higher sensitivity, specificity, and diagnostic accuracy; than P/F ratio making it more reliable predictor. At a cutoff point of ≤303.33, the S/F ratio was the best predictor for the need for HFNC, with an area under the curve (AUC) of 0.966, indicating excellent predictive accuracy.

The S/F ratio offers a practical, non-invasive alternative for predicting not only the need for HFNC, but also for estimating ICU admission, hospital stay, and the number of days on HFNC. This makes it a highly useful non-invasive tool in managing children with respiratory distress.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Ware LB, Matthay MA. The acute respiratory distress syndrome. N Engl J Med. 2000;342:1334–49.
2. Bernard GR, Artigas A, Brigham KL, Carlet J, Falke K, Hudson L. et al. Thoracic SoG-The American European Consensus Conference on ARDS efinitions, mechanisms. Am J Respir Crit Care Med. 1994;149:818–24.
3. Pandharipande PP, Shintani AK, Hagerman HE, Jacques PJ, Rice TW, Sanders NW, et al. Derivation and validation of Spo2/Fio2 ratio to impute for pao2/fio2 ratio in the respiratory component of the sequential organ failure assessment score. Crit Care Med. 2009;37(4):1317–21.
4. Lohano PD, Baloch SH, Gowa MA, Raza SJ, Soomro L, Nawaz H. Correlation between the ratio of oxygen saturation to fraction of inspired oxygen and the ratio of partial pressure of oxygen to fraction of inspired oxygen in detection and risk stratification of pediatric acute respiratory distress syndrome. Cureus. 2021;13(9):18353.
5. Mayordomo-Colunga J, Pon, López Y, et al. Predicting non-invasive ventilation failure in children from the SpO, /FiO, (SF) ratio. Intensive Care Med. 2013;39:1095-103.
6. Lobete C, Medina A, Rey C, Mayordomo-Colunga J, Concha A, Menéndez S. Correlation of oxygen saturation as measured by pulse oximetry/fraction of inspired oxygen ratio with PaO2/fraction of inspired oxygen ratio in a heterogeneous sample of critically ill children. J Crit Care. 2013;28:538.
7. Babu S, Abhilash KPP, Kandasamy S, Gowri M. Association between SpO2/FiO2 Ratio and PaO2/FiO2 Ratio in Different Modes of Oxygen Supplementation. Indian J Crit Care Med. 2021;25(9):1001–5.
8. Beniwal R, Batra P, Bhaskar V, Harit D. SpO2/FiO2 and PaO2/FiO2 for Predicting Intensive Care Admission in Wheezy Children: An Observational Study. Indian Pediatr. 2024;61(7):632-6.
9. Khemani RG, Patel NR, Bart RD, Newth CJ. Comparison of the pulse oximetric saturation/fraction of inspired oxygen ratio and the PaO2/fraction of inspired oxygen ratio in children. Chest. 2009;135(3):662-8.
10. Chang CC, Lin YC, Chen TC, Lin JJ, Hsia SH, Chan OW. High-flow nasal cannula therapy in children with acute respiratory distress with hypoxia in a pediatric intensive care unit–a single center experience. Front Pediatr. 2021;9:664180.
11. Kim, G.E., Choi, S.H., Park, M. et al. SpO2/FiO2 as a predictor of high flow nasal cannula outcomes in children with acute hypoxemic respiratory failure. Sci Rep. 2021;11:13439.
12. Shah N, Sarangi BU, Shankar GH. Comparison of PaO2/FiO2 (PF ratio) to SpO2/FiO2 (SF ratio) and OI to OSI for Predicting Short Term Outcomes in Children with Acute Hypoxemic Respiratory Distress: A Prospective Observational Study. Indian J Pediatr. 2024;3:56-8.

Cite this article as: Balleda L, Ijjada A, Kolla S, Thimmapuram CSR. The utility value of SpO2/FiO2 (S/F) and PaO2/FiO2 (P/F) ratios for predicting initiation and efficiency of HFNC in children with respiratory distress admitted in PICU. Int J Contemp Pediatr 2025;12:609-14.