Validation of AIOS (acute illness observation scale) score with radiological findings and pulse oximetry in community acquired pneumonia (cap) among children aged 2 to 24 months

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Abstract:Background: *Pneumonia accounts for a significant proportion of the disease burden attributed to acute lower respiratory infections.In order to optimise criteria for hospitalisation and initial therapy, use of Acute Illness Observation Scale (AIOS) -a simple and objective illness severity scale is validated using pulse oximetry and radiological findings.*
Methods:*All children between 2 –24 months, admitted to the children ward with suspected pneumonia were enrolled into the study. Pulse oximetry reading on admission was noted. Acute Illness Observation Scale scoring used to score severity of illness at admission and after 24 hours and 96 hours of admission. Patients were followed up till the time of discharge from hospital / death. Results wereanalysed for the extent to which chest X-ray and pulse oximetry readings correlate to the AIOS score thereby indicating severity of pneumonia.*
Results:*In infants pulse oximeter reading<85% better predicted endpoint consolidation and complications.Pulse oximeter reading<92% is more specific (90%) in children with more than 12 months age for predicting endpoint consolidation in x-ray than in infants. AIOS score correlated well with Pulse oximeter readings (p<0.01, Karl Pearson correlation = - 0.65) and abnormal X-ray findings (p<0.01, Karl Pearson correlation = 0.46). AIOS score>10 is more sensitive and less specific in predicting abnormal X-ray than pulse oximetry alone. AIOS score>15 is significantly associated with poor clinical course, complications, prolonged hospital stay and culture positive pneumonia.*
Conclusion:*AIOS scoring can be used by the treating physician not only in deciding on therapeutic modalities but also to prognosticate a child admitted to the hospital with pneumonia with an approximate duration of hospital stay that may be required.*
Key words: *Acute Illness Observation Scale, Pneumonia, Pulse oximetry*

I. Introduction

Respiratory infections are common among infants and "Pneumonia[1]" has become the most common reason parents cite for taking their children to see the general practitioner, and to attend pediatric emergency with a medical problem. Pneumonia accounts for 16 per cent of all under-five deaths and killed about 922,000 children in 2015. Most of its victims were less than 2 years old.[2].

Hence gaining an objective understanding of well-being of a child with pneumonia is essential to optimize criteria for triage, early referral, hospitalization and initial therapeutic modalities in less-developed countries.

In this regard, use of Acute Illness Observation Scale (AIOS)[3] -a generic illness severity scale, represents a distinctive paradigm drawn on simple observations (based on clinical appearance) instead of complex symptomatology, aiming for wholeness rather than details and encompassing the entire not just the ends of sickness continuum. AIOS (a three-point scale for six ordinal variables and total score range of 6 to 30) is a validated clinical index of quantifying risk of serious bacterial infections (SBI) in children 36 months or younger presenting with febrile illnesses [3]. Incidence of serious bacterial infections (SBI) is less than 2-3% if a febrile child scores 10 or less; and more than 90% if AIOS score is 16 or above[3].

II. Aim and objectives

Aimof the study
1. To validate AIOS (Acute illness observation scale) score with Radiological findings and Pulse oximetry in Community acquired Pneumonia (CAP) among children aged 2 to 24 months.

Objective of the study
1. To assess the outcome of management of community acquired pneumonia by grading the severity of community acquired pneumonia.

III. Material &Methods

Study population: Children aged 2 to 24 months
Study design: Descriptive epidemiology study
Sample size: 200
In the last 1 year around 400 cases of children of age group 2-24months were admitted with fever, cough and tachypnea to our Paediatric department . Keeping the population as 400 and confidence level of 95% and confidence interval of 5% the sample size will be 197 rounded off to 200 (using sample size calculator).
Study period: Over a period of 18 months
Inclusion criteria: Children between 2 months to 24 months presenting with fever, tachypnea*, and/or cough and/or difficult breathing
* Tachypnea: 2months-12months >50/min
  12months-5years >40/min

Exclusion criteria:
1. Duration of illness >2weeks
2. Known asthmatics/wheezers
3. Cardiac disease

Methodology
      All children between 2 –24 months, admitted to the children ward with suspected pneumonia were enrolled into the study. Pulse oximetry reading on admission was noted. Printed charts containing Acute Illness Observation Scale scoring (McCarthy et al) used to score severity of illness. Scores were recorded after 24 hours of admission and after 96 hours of admission. Findings were recorded along with respiratory parameters and pulse oximetry readings, vital signs, treatment, investigations like Chest x-ray, Complete blood count, blood culture and disease course as in data collection form . Patients were followed up till the time of discharge from hospital / death. Results were analyzed for the extent to which chest X-ray and pulse oximetry readings correlate to the AIOS score thereby indicating severity of pneumonia.

Statistical analysis: &**Statistical methods:**
Descriptive and inferential statistical analysis were carried out in the present study. Following statistical methods were applied in our present study:
1. Chi-Square Test
2. Fisher Exact Test
3. Pearson correlation
4. ANOVA test
5. Diagnostic statistics
Significant figures:
* Moderately significant (P value: $0.01 < P < 0.05$)
** Strongly significant (P value: $P < 0.01$)
For calculation we used Microsoft EXCEL, WORD and a statistical software "MedCalc" .

IV. Observations and results
      After exclusion of 28 children who had associated cardiac problems and positive for gastroesophageal reflux, 200 children were enrolled into the study. Statistical analysis was done using computerized software and results are presented as follows

General characteristics

Demographic characteristics
Age and sex:
    The age in the study group ranged from 2months to 24 months (10.11 ±7.11 months) and infants 2-12 months constituted 66%of the study group.
Male children were predominant (63.5%) with a male to female ratio of 1.74:1.

Nutritional status

33% of the study group (66/200) were between 15-50th percentile as per WHO weight for age chart. Only 2% of the cases were above 97th percentile. However a significant number were below the 3^{rd}percentile constituting 32% of the study group.

Clinical features
History and Symptoms

Fever and cough was the common presenting symptom. While cough was present in all patients, fever was absent in 7.5% of study group. In those children who had fever the duration of fever varied between1 to 10 days (3.67± 2.5 days). In 92.5% cases the fever had not been measured using thermometer and the symptom was a subjective sensation perceived by the care takers.Duration of cough varied between 1 to 12 days (4.9± 2.75 days). Tachycardia for corresponding age was found in 70 patients (35%). Regarding other respiratory signs majority had Chest retractions(81%)andtachypnea was present in 79% of the patients. Grunting was observed in 80 children (40%) and peripheral cyanosis in6%.

Course of the illness:

During their management 4% (8/200)of children were so severely affected that they needed mechanical ventilation for respiratory failure or shock management and 4%(8/200) needed inotropic support for shock management. Oxygen was administered for 55% (110/200) of cases in view of severe respiratory distress or cyanosis. During the hospital stay 8% (16/200) developed complications either in the form of pneumothorax, empyema and lung abscess .The mean duration of hospital stay (±SD) was 6.35 (±4.0) days.

Blood investigations:

Among other investigations, leucocytosis was seen in 41% (82/200), and a positive blood culture in 4% of cases and 43 % of children had moderate anemia as classified by WHO.

Pulse oximetry

Pulse oximeter recording was taken in all children on admission. A reading below 85%$Spo_2$was observed in 8% (16/200) of cases. Spo_2 recording of ≥92 was seen in 60% (120/200) and the remaining had an oxygen saturation in between 85 to 91%.Infants constituted 66 out of 80 cases (82.5%) of the patients having recorded Spo_2 of < 92%, which is statistically significant (p < 0.01). Pulseoximetry value as a single indicator proved to be statistically significant on correlating SPO_2 value with each of the above parameters.

Chest X-ray

Chest X-ray evaluation was done in all patients at admission. Normal CXR finding were present in 29% (58/200) and remaining 71% (142/200) had significant abnormalities.
Among the X-ray abnormalities End- point consolidation was seen in 39% (78/200) while other non-end point infiltrates was seen in 32% (64/200).

Relation of Pulse oximetry and Chest X-ray finding in study population:

Spo2 reading of < 92% on admission predicted abnormal chest x- ray in 66 out of80 patients (82.5%) with specificity of 76% and sensitivity of 46.5%.Karl Pearson correlation of $SpO_2$with Chest X-ray was -0.50 s/o moderate correlation.

Table-1:Relation between Chest x ray findings and Pulse oximetry

CHEST X RAY	SPO2 ON ADMISSION(n=200)						p value
	≥92(120)		85-91(68)		<85(12)		
	NO.	%	NO.	%	NO.	%	
NORMAL	44	36.7	12	17.6	2	16.7	0.01
ABNORMAL	76	63.3	56	82.4	10	83.3	

In infants for predicting end point consolidation, pulse oximetry reading with Spo_2<92 has asensitivity of 64% and specificity of 60%. Whereas in children aged 13 to 24 months for predicting end point consolidation, pulse oximetry reading with Spo_2<92 has a Sensitivity of 30% and specificity of 90%.Among 12 patients of 2 – 12 months age who presented with SPO_2<85% on admission 10 patients had an abnormal CXR

(2 non endpoint and 10 endpoint). Among 14 patients of 13 -24 month age group who presented with $spo_2 < 92\%$ on admission 10 patients had an abnormal chest x ray.

Table-2: Relation of Pulse oximetrywith complications with age

SPO2 WITH COMPLICATIONS WITH AGE				
AGE in months		SPO2		
		≥92	85-91	<85
2--12	TOTAL NUMBER	66	54	12
	WITH COMPLICATIONS	2	2	4
>12	TOTAL NUMBER	54	14	0
	WITH COMPLICATIONS	2	6	0

Among patients who had hypoxemia on admission(SPO2< 92%), complications of pneumonia developed in 42.8% of patients of > 12 months age and only in 9% of Infant age group, of which 67% had severe hypoxemia(<85%) on admission.

Among patients who had hypoxemia on admission(SPO2< 92%),Respiratory distress persisted for ≥5 days in 42% of patients of > 12 months age and only 21% of Infant age group, of which 57% had severe hypoxemia(<85%) on admission.

SPO2 in predicting duration of hospital stay

Table-3: Relation of Pulse oximetry with duration of hospital stay

SPO2 READING		HOSPITAL STAY(IN DAYS)				
		1--5	6--14	>14	TOTAL	p VALUE
≥92	NO.	72	44	4	120	
	%	60	36.7	3.3		
85-91	NO.	26	40	2	68	0.00016
	%	38.2	58.8	3		
<85	NO.	0	12	0	12	
	%	0	100	0		

Out of 120 patients who had SPO2 reading of > 92% on admission, 60% had a hospital stay of less than 5 days. Whereas in 80 patients who had SPO2< 92% on admission 65% had a hospital stay of more than 5 days, suggesting a statistically significant increase in duration of hospital stay in patients who had hypoxemia on admission.

AIOS and pulse oximeter correlation

Relating children's score against their pulse oximeter recording on admission, severe hypoxemia (SPO2<85) was observed in 12 children of which 66.7% (8) scored a high value on AIOS (AIOS≥16) whereas 50.0% of children scored normally on AIOS among the group of 120 with a $SPO_2 > 92\%$. In predicting hypoxemia ($SPO_2 < 92\%$), AIOS score > 10 has 100% sensitivity and 50% specificity.Karl Pearson correlation of AIOS with Spo_2 Reading was-.65 s/o good correlation.

Table-4: AIOS and pulse oximeter correlation

SPO2 ON ADMISSION	AIOS SCORE ON DAY1						P value
	6--10 (n=60)		11--15 (n=86)		>15 (n=54)		
	no.	%	no.	%	no.	%	
≥92	60	50	54	45	6	5	
85-91	0	0	28	41.2	40	58.8	<0.01
<85	0	0	4	33.3	8	66.7	

AIOS correlation with chest X-ray

Relating children's score against their radiologic finding to assess the concurrent validity, 48.2% children with normal CXR had AIOS of ≤10 whereas 22.5% had normal scores in the group of abnormal CXR

finding(P<0.001). In predicting abnormal chest x-ray, Sensitivity of AIOS score > 11 was 77%, Specificity was 48%. Karl Pearson correlation of AIOS with Chest x-ray was 0.46 s/o good correlation with p<0.01.

Table-5: AIOS correlation with chest X-ray

Investigation		AIOS score on day 1						Total	P Value
		6--10(n=60)		11--15(n=86)		>15(n=54)			
		No.	%	No.	%	No.	%		
Chest x ray	Normal	28	48.3	24	41.4	6	10.3	58	<0.0001
	Endpoint	6	7.7	32	41	40	51.3	78	
	Non-endpoint	26	40.6	30	46.9	8	12.5	64	

AIOS in predicting persistent distress on day5

Among the 200 who scored AIOS<10 No one had distress persisting on day 5, while out of the 86 who scored 11-15 on AIOS 6.9% had distress persisting. In the worst group of AIOS score, out of the 54 cases 31.4% had distress persisting on day 5 which is statistically significant (P<0.001)

AIOS in predicting complications

Complications were absent in those who scored ≤10, while maximum complicationswere seen in those who scored ≥16.

Table 6: AIOS in predicting complications

DISEASE COURSE	AIOS SCORE ON DAY1						TOTAL	P value
	6--10 (N=60)		11--15 (N=86)		>15 (N=54)			
	no.	%	no.	%	no.	%		
DISTRESS ON DAY 5	0	0	6	6.9	17	31.4	23	0.0001
COMPLICATIONS	0	0	6	6.9	10	18.5	16	0.0012

AIOS in predicting duration of hospital stay

Out of the 60 who scored ≤10 on AIOS 70% had a hospital stay of ≤5 days, while those scored the worst 74.1% had a stay duration of 6- 14 days and 3.7 % had >14 days hospital stay duration.

AIOS score with bacteremia and complications

Among children who scored AIOS>11, six out of eight (75%) infants who developed complications in the form of pleural effusion and pneumothorax had culture positive streptococcal sepsis. Two of the remaining had sterile blood cultures. Among children aged 13 to 24 months though 8 children developed complications in the form of pleural effusion and lung abscess blood cultures were sterile in all of them.

Relation of nutritional status, Pulse oximetry and AIOS score

In our study it was found that 3 parameters namely weight percentile, SpO_2<92% and the AIOS score>15 together predicted 100% of the complications thereafter. In those cases where there was neither hypoxia nor AIOS>15 it was found that the weight of the child was below the 3 rd percentile weight for age and sex.

V. Discussion

Among 200 enrolled children in this study 40% of patients had hypoxemia. This was in comparison with studies done by Salah et al (42.7%)[4]and Basnet S et al(38.7%)[5].

There were a significantly higher number of infants (82.5%) in our study who had hypoxemia. Infants are vulnerable to acute respiratory infections because, not only do they have less mature immune systems [6] but are also unable to clear secretions. Age below 12 months has been identified as a predictor of mortality in children with pneumonia.[7]

In our study majority (55%) of admissions were between the months of December to March which coincides with the peak winter season. The patients are covered with several layer of clothing which masks the chest retractions and therefore the caretaker is not able to identify the respiratory distress. Also we assume that infants cannot verbally communicate their distress and the mother continues to breastfeed the baby predisposing

to aspiration. These factors may be the reason that some infants present with profound hypoxemia on arrival at the hospital. Other studies on hypoxemia in children with ARI have not assessed the role of age as a risk factor.

Lethargy, cyanosis, grunting, chest retractions, tachypnea, tachycardia, crepitations on auscultation had significant association with hypoxemia (p<0.05) in our study. This observation was similar to the studies done by Basnet S et al[5](p<0.05) and Lodha R et al(p<0.05)[8].

Pulse oximetry and Chest X-ray:

In our study SpO$_2$ reading of < 92% (n=80) on admission predicted abnormal chest x- ray in 82.5% patients with specificity of 76% and sensitivity of 46.5%. In infants when Spo$_2$ readings were below 85% (n=12) end point Chest x ray was found in 75% (8/12) of them. Complications (33%) and prolonged distress (75%) also was higher in the infants with spo2<85%.

AIOS score:

AIOS scoring has a good correlation with initial pulse oximeter reading and decision regarding supplementation of oxygen. In this study we found good correlation between AIOS with Chest X-Ray (p<0.01, Karl Pearson correlation = 0.46). AIOS with Spo2 reading showed a good correlation (p<0.01, Karl Pearson correlation = - 0.65) indicating that high AIOS scores are associated with low SpO$_2$ scores there by denoting more severe respiratory illness. However pulse oximetry with chest X-ray (non endpoint + endpoint) showed moderate correlation (p<0.01, Karl Pearson correlation = - 0.5).

In predicting abnormal chest X ray, Sensitivity of AIOS score > 11 was 77%, Specificity was 48%. Again as noted above in our study SpO$_2$ reading of < 92% (n=80) on admission predicted abnormal chest x- ray in 82.5% patients with specificity of 76% and sensitivity of 46.5%.Therefore pulse oximetry as a tool to predict Severity of respiratory illness is more specific than sensitive.

In our study culture positivity was 4% in total population, It increased to 11% in children who scored AIOS>15. It is in comparison with the study done by Iroh Tam PY[9] where cultures were positive in 9.89% in severe pneumonia .On comaparing AIOS score with Chest x-ray abnormalities and therapeutic modalities there was a significant correlation. Hence it can be utilized to decide on initial therapeutic decision like antibiotics, oxygen requirement and other modalities, hence it can be a useful tool in the absence of chest X-ray facilities.

Regarding the ability of AIOS score to predict clinical outcome the persistence of respiratory distress on day 5 of hospital stay distress was present in 31.4% of those children scored AIOS≥16 which was statistically significant. Hence repeated x-ray evaluation can be avoided to prevent unnecessary exposure to harmful radiations in a child with pneumonia, continued antibiotic usage could be justified. Therefore though AIOS can predict clinical outcome in children with pneumonia, it is more effective in combination with initial pulse oximetry findings.

AIOS predicted the length of hospital stay with maximum duration of stay in those with a worst AIOS score. AIOS scoring can be used by the treating physician not only in deciding on therapeutic modalities but also to prognosticate a child admitted to the hospital with pneumonia with an approximate duration of hospital stay that may be required.

Similarly on predicting complications maximum numbers of complications were present in those with AIOS score ≥16 which was statistically significant.

However we found that 6 out of 8(75%) infants who developed complications in the form of pleural effusion and pneumothorax had culture positive streptococcal sepsis. Two of the remaining had sterile blood cultures. Among children aged 13 to 24 months though 8 children developed complications in the form of pleural effusion and lung abscess blood cultures were sterile in all of them.

On combining AIOS score >15 with SPO2<92 the predictability of complications increased to 88%. Further addition of another parameter namely the pre illness weight of the child <3rd percentile weight for age and sex 100% of the complications could be predicted. Therefore these children inspite of a relatively better AIOS and better oxygen saturation levels would require aggressive therapy in the form of Oxygen, IV antibiotics and supportive therapy preferably at referral centres from primary health centres.   Study by Lazzerini M[10] in a systemic review and meta analysis of hypoxemia as a mortality risk factor in acute lower respiratory infection in children in low and middle income countries has concluded that a spo2 value of 92% and 90% identify children at increased risk of mortality. Therefore the need for regular use of Pulse oximetry and availability of oxyen to decrease mortality has been emphasized. Similarly Zhang L[11] has also expressed that improved access to pulse oximetry is needed in developing countries.

India being among the developing nations with a paucity of health care services at distant rural areas would benefit by the combination of pulse oximetry, AIOS score and nutritional assessment to use the judicious resources of oxygen and referral mechanisms to salvage more children.

VI.   Conclusion

1. Hypoxemia is significantly associated with clinical signs like tachypnea, tachycardia, chest retractions, grunting, lethargy and crepitations ($p < 0.05$).
2. Hypoxemia is significantly associated with abnormal chest x-ray findings. Pulse oximeter reading<92% is more specific in children with more than 12 months age for predicting endpoint consolidation in x-ray than in infants. In infants pulse oximeter reading<85% better predicted endpoint consolidation and complications.
3. AIOS score>15 is significantly associated with poor clinical course, complications, prolonged hospital stay and culture positive pneumonia.
4. AIOS scoring can be used by the treating physician not only in deciding on therapeutic modalities but also to prognosticate a child admitted to the hospital with pneumonia with an approximate duration of hospital stay that may be required.

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