ORIGINAL RESEARCH

Prediction of Retinopathy of Prematurity in Single and Twin Babies: The Predictive Accuracy of WINROP

S Mohan[1], Kalpana Badami[1], Pavan Kuman[1], Shilpa YD[1], Hemalata BC[1], Kavitha Tumbadi[1]

Received on: 22 December 2023; *Accepted on*: 23 January 2024; *Published on*: 26 March 2024

Abstract

Aim: To test the effectiveness of WINROP software tool to screen retinopathy of prematurity (ROP) in Indian preterm infant population including twin neonates.

Materials and methods: In a retrospective single-center study, birth weight (BW), gestational age (GA), comorbidities, and weekly weight measurements (for 5 weeks) were retrieved from 63 preterm infants born between 01/2014 and 04/2015. The obtained data were entered into the WINROP algorithm to obtain ROP outcomes and WINROP alarm.

Results: For a cohort of 63 patients together with twin neonates, the median BW was 1250 gm and GA was 30 weeks. Of the 63 infants, 22 infants developed type I ROP and 39 infants developed type II ROP. WINROP alarm was triggered in 33 (52.38%) infants. Comorbidities, such as malnutrition, respiratory distress syndrome (RDS), blood transfusion, anemia of prematurity, and pregnancy-induced hypertension (PIH) were associated with the development of ROP. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of WINROP to predict type I ROP were 63.6, 53.6, 42.4, and 73.3%, respectively. In twin neonates, WINROP predicted type I ROP with sensitivity, specificity, PPV, and NPV of 100, 60, 33.3, and 100%, respectively.

Conclusion: This is the first WINROP validation study in twin neonates from Indian settings. The WINROP model was highly sensitive to detect type I ROP in twin neonates. However, due to low specificity and low PPV, the outcome of this study suggests the use of WINROP algorithm alongside standard ROP screening in infants including twin neonates with WINROP alarm.

Keywords: India, Retinopathy of prematurity, Twins, Type I ROP, WINROP.

Newborn (2024): 10.5005/jp-journals-11002-0084

Introduction

Retinopathy of prematurity (ROP), a gestational age (GA)-related illness, is a leading cause of childhood blindness in premature infants.[1] Pathologically, ROP involves delayed retinal vascularization, vaso-proliferation, and intravitreal angiogenesis.[2] Fibrovascular retinal detachment and permanent blindness are the risks associated with ROP.[2] Among the risk factors, low GA, low birth weight (BW), and oxygen level are the major risk factors for the development of ROP.[1] Timely screening of premature infants for ROP could improve visual prognosis. The conventional ROP screening involves dilation of pupil and subsequent use of indirect ophthalmoscopy and retinal imaging using a RetCam.[3] However, to minimize the risk and to increase the identification of high-risk infants, researchers have introduced and developed multiple prediction models, such as WINROP, CO-ROP, ROP Score, and CHOP-ROP.[1] Several studies have show that the WINROP model may have sensitivity levels as high as 80–90% in preterm infants.[4–6]

Since, low GA and low BW are the major risk factors in the development of ROP, WINROP prediction model uses weight and GA at birth as a dichotomized factor for the screening of ROP.[7] However, studies indicate that heavier and more mature babies can also develop ROP, especially, from middle-income or developing countries such as India indicating the role of alternative risk factors in the development of ROP.[1] Thus, to accommodate larger number of ROP screening, the National guidelines for the screening for ROP has broad eligibility criteria with GA of ≤34 weeks or <2000 gm or neonates with GA above 34 weeks and associated risk factors, such as prolonged oxygen support, cardiovascular instability, and sepsis.[3]

[1]Department of Vitreo-Retina, Minto Ophthalmic Hospital, Bengaluru, Karnataka, India

Corresponding Author: S Mohan, Department of Vitreo-Retina, Minto Ophthalmic Hospital, Bengaluru, Karnataka, India, Phone: +91 7406413111, e-mail: smohanms17224w@gmail.com

How to cite this article: Mohan S, Badami K, Kumar P, *et al*. Prediction of Retinopathy of Prematurity in Single and Twin Babies: The Predictive Accuracy of WINROP. Newborn 2024;3(1):3–7.

Source of support: Nil

Conflict of interest: None

In the last 5 years, several clinical studies performed in India have adopted the WINROP model[8,9] and have shown high sensitivity and NPV of the algorithm to predict type I ROP. The model was sensitive to predict type I ROP earliest at 2 weeks than the conventional screening which predicted ROP at 7th week postnatal stage.[9] However, there is scarcity of relevant-studies and the existing literature does not completely validate the adoption of WINROP in Indian settings.

Aim and Objectives

The aim of the present study was to test the efficacy of WINROP to predict ROP in Indian preterm infant population. The objective was (i) to investigate the pattern of ROP in preterm infant population including twin neonates and (ii) to measure the diagnostic performance of WINROP software to predict ROP in twin neonates.

Materials and Methods

This was a retrospective study conducted on 63 infants born between 01/2014 and 04/2015 and who were at high risk of developing ROP. Infants with the following criteria were included: (i) BW less than 1500 gms; (ii) GA 30 weeks; (iii) infants with BW between 1500 gm and 2000 gm or (iv) GA more than 30 weeks and with an unstable clinical course and at high risk for ROP. The enrolled infant population also included 6 pairs (12 infants) of twin neonates with ROP. Twins were called discordant if their BW difference was more than 15%. For twins, the inclusion criteria were that both twin infants were alive. Infants with congestive heart failure, neonatal nephrotic syndrome, hydrocephalus were excluded due to nonphysiologically weight gain. Data of final ROP outcome should be available.

WINROP Screening

For WINROP screening, following clinical data were retrospectively retrieved including infant's GA (less than 32 weeks at birth), BW, associated comorbidity, weekly weight measurements, physiological weight gain and absence of other pathologic retinal vascular disease. The collected data were entered into WINROP software (https://winrop.com/). Clinical examination for ROP was performed weekly/twice in a week and close observation was made to see the progression of ROP to type I ROP. The clinical phenotypes of ROP, namely, type I and type II ROP were classified as per the Early Treatment of Retinopathy of Prematurity (ETROP) cooperative group classification.

Statistical Analysis

The Statistical Package for Social Sciences (SPSS) version 24 was used for descriptive statistics. Association between the variables was estimated by Chi-square analysis. Independent *t*-test was performed to evaluate the differences in variables between with and without WINROP group. The sensitivity, specificity, PPVs, and NPVs of the WINROP algorithm were also calculated.

Results

Table 1 illustrates the demographic characteristics and ROP outcomes in 63 preterm infants who were enrolled in this study. The majority were female infants (53.9%) with very low BW in the range of 1000–1500 gm (69.8%). The median GA was 30.0 weeks (30.0–32.0 weeks) and the median BW was 1250 gm (range: 1052.5–1500.0 gm). The median BW in the first week was 1310 gm (1100.0–1547.50 gm) which increased to 1587 gm (range: 1353.75–1797.5 gm) in the fifth week. Based on birth plurality, out of 63 preterm infants, 51 were single babies and 12 (6 pairs) were twin babies. WINROP alarm was signaled in 52.3% of infants and 39 (61.9%) infants developed type II ROP, 22 (34.9%) developed type I ROP and 2 (3.1%) had no ROP.

Table 1: Demographic characteristics

	Frequency (%)
Birth weight	
ELBW	5 (7.94)
LBW	14 (22.22)
VLBW	44 (69.84)
Gender	
Male	29 (46.03)
Female	34 (53.97)
WINROP	
Alarm	33 (52.38)
No alarm	30 (47.62)
Birth plurality	
Single	51 (80.95)
Twins	12 (19.05)
Type of ROP	
No ROP	2 (3.17)
Type II ROP	39 (61.9)
Type I ROP	22 (34.92)
Median (IQR)	
Gestational age (weeks)	30.000 (30.000–32.000)
Birth weight (BW in gm)	1250.00 (1052.50–1500.00)
Weight in week 1	1310.00 (1100.00–1547.50)
Weight in week 2	1365.000 (1157.50–1608.75)
Weight in week 3	1440.00 (1203.75–1682.5)
Weight in week 4	1495.00 (1263.75–1732.5)
Weight in week 5	1587.50 (1353.75–1797.5)

Association between Birth Characteristics and WINROP

Table 2 presents the association of birth characteristics and type of ROP with and without WINROP alarm. There was no association of WINROP alarm with sex ($\chi^2 = 0.009$, $p > 0.05$), BW ($\chi^2 = 3.171$, $p > 0.05$) and type of ROP ($\chi^2 = 3.527$, $p > 0.05$). Further, GA ($t = -1.238$, $p > 0.05$), BW ($t = -1.788$, $p > 0.05$) and physiological weight gain from 1st week to 5th week were not associated with WINROP alarm ($p > 0.05$).

Association between Type of ROP and Comorbidities

Infants had multiple comorbidities including RDS (76.1%), followed by blood transfusion (44.4%) anemia of prematurity (42.8%), hyaline membrane disease (23.8%) and malnutrition (22.2%). In addition, about 76.1% of infants were born to mother with PIH. ROP showed highly significantly association with malnutrition ($\chi^2 = 20.46$, $p < 0.001$), RDS ($\chi^2 = 9.33$, $p < 0.001$) and anemia of prematurity ($\chi^2 = 9.58$, $p < 0.001$) and significant association with blood transfusion ($\chi^2 = 6.48$, $p < 0.05$) and PIH ($\chi^2 = 7.28$, $p < 0.05$). Type I ROP was associated with malnutrition and anemia of prematurity and type II ROP was associated with RDS, blood transfusion and PIH.

Effectiveness of WINROP to Predict ROP

WINROP alarm was signaled in 33 infants, out of which 14 (42.4%) developed type I ROP and 19 (57.6%) developed non-type I ROP. About 8 infants developed type I ROP without any WINROP alarm. In the prediction of type I ROP, WINROP tool had a sensitivity of 63.6%, specificity of 53.6%, PPV of 42.4% and the NPV of 73.3% (Table 3).

WINROP Analysis for Twin Neonates

Table 4 presents the association of birth characteristics and type of ROP with and without WINROP alarm in twin neonates. Sex and type of ROP were not associated with WINROP alarm. The association of WINROP alarm with BW was significant ($\chi^2 = 4.00$, $p < 0.05$). WINROP alarm was signaled in twins with very low BW suggestive of high risk of ROP in infants with very low BW (1000–1500 gm). Further, the *t*-test showed significant difference in BW between infants with and without WINROP alarm ($t = -2.533$, $p < 0.05$) (Table 4).

Table 2: Association of birth characteristics and type of ROP with WINROP

	WINROP		*Chi-square/ t-value*	*p-value*
	Alarm	*No alarm*		
Sex				
Male	15 (51.7%)	14 (48.3%)	0.009	0.923
Female	18 (52.9%)	16 (47.1%)		
Birth weight				
ELBW	4 (80%)	1 (20%)	3.171	0.205
LBW	5 (35.7%)	9 (64.3%)		
VLBW	24 (54.5%)	20 (45.5%)		
Type of ROP				
No ROP	0 (0%)	2 (100%)	3.527	0.171
Type II ROP	19 (48.7%)	20 (51.3%)		
Type I ROP	14 (63.6%)	8 (36.4%)		
Birth weight	1197.72 ± 292.73	1325.33 ± 271.54	–1.788	0.079
Gestational age	31.0 ± 1.73	31.60 ± 2.11	–1.238	0.221
Weight in 1st week	1275.15 ± 305.78	1377.32 ± 272.82	–1.357	0.180
Weight in 2nd week	1324.39 ± 302.93	1433.92 ± 273.08	–1.472	0.146
Weight in 3rd week	1388.42 ± 301.96	1498.21 ± 276.06	–1.471	0.146
Weight in 4th week	1442.87 ± 312.96	1555.89 ± 277.51	–1.480	0.144
Weight in 5th week	1515.42 ± 308.59	1628.57 ± 276.70	–1.496	0.140

Table 3: Sensitivity, specificity, PPV, and NPV in predicting type I ROP using the WINROP

	ROP			*Sensitivity (%)*	*Specificity (%)*
	Type I ROP	*Non-type I ROP*	*Total*		
WINROP					
Alarm	14	19	33	63.64	53.66
No alarm	8	22	30		
Predictive value (%)					
PPV	42.4				
NPV	73.3				

NPV, negative predictive value; PPV, positive predictive value

Table 4: Association between birth characteristics of twins and type of ROP with WINROP

	WINROP		*Chi-square/ t-value*	*p-value*
	Alarm	*No alarm*		
Sex				
Male	0 (0%)	2 (100%)	2.400	0.121
Female	6 (60%)	4 (40%)		
Birth weight				
LBW	0 (0%)	3 (100%)	4.000	0.046
VLBW	6 (66.7%)	3 (33.3%)		
Type of ROP				
No ROP	0 (0%)	2 (100%)	4.000	0.135
Type II ROP	4 (50%)	4 (50%)		
Type I ROP	2 (100%)	0 (0%)		
Gestational age (GA)	30.6 ± 2.0	33 ± 2.4	–1.784	0.105
Birth weight (BW)	1092.5 ± 90.76	1410 ± 293.25	–2.533	0.030
Weight in week 1	1170.0 ± 85.3	1397.5 ± 272.4	–1.788	0.117
Weight in week 2	1201.6 ± 99.2	1455.0 ± 266.6	–2.166	0.062
Weight in week 3	1270.8 ± 95.8	1522.5 ± 276.9	–2.099	0.069
Weight in week 4	1323.3 ± 105.8	1583.7 ± 265.1	–2.209	0.058
Weight in week 5	1390.8 ± 101.3	1653.7 ± 270.0	–2.217	0.057

The mean value of BW was lower in WINROP alarm group than no alarm group (1092.5 ± 90.7 vs 1410 ± 293.2 gm).

In 6 pairs (12 babies) of twin babies, RDS (83.3%), anemia of prematurity (75%), and hyaline membrane disease (50%) were the most frequent comorbidities. Among the comorbidities in twin babies, malnutrition ($\chi^2 = 12.00$, $p < 0.001$) and PIH ($\chi^2 = 7.33$, $p < 0.05$) showed significant association with type I ROP, and RDS ($\chi^2 = 12.00$, $p < 0.001$) and anemia of prematurity ($\chi^2 = 7.33$, $p < 0.05$) showed significant association with type II ROP.

In twin neonates, WINROP alarm was signaled in six infants, out of which two developed type I ROP and six infants with no alarm developed non-type I ROP. The diagnostic performance of WINROP indicated sensitivity of 100%, specificity of 60%, PPV of 33.33%, and NPV of 100% to predict type I ROP (Table 5).

Discussion

Clinically, prediction models such as WINROP have been used to detect the risk of ROP in preterm infants.[5,10] The present retrospective study was performed to analyze the predictive ability of WINROP algorithm for the detection of ROP in preterm infant babies in Indian setup. The median BW of 1250 gm and GA of 30 weeks were comparable to studies from other Asian population including China[11] and Taiwan.[12] WINROP alarm was signaled in 52.3% of infants which was low compared with previous studies from Malaysia (72.8%),[13] India (74.2%),[8] and Saudi (70.9%)[14] but

Table 5: Sensitivity, specificity, PPV, and NPV in predicting type I ROP using the WINROP

	ROP			Sensitivity	Specificity
	Type I ROP	*Non-type I ROP*	*Total*	*(%)*	*(%)*
WINROP					
Alarm	2	4	6	100	60
No alarm	0	6	6		
Predictive value (%)					
PPV	33.33				
NPV	100				

higher than percent of WINROP alarm in the study from Australia (42.6%)[6] and another study from India (27.7%).[15] In the present study, WINROP alarm showed no association with BW ($p > 0.05$), sex ($p > 0.05$) and type of ROP ($p > 0.05$). Contrary to the present finding Sute et al.[15] showed association of WINROP alarm with gestation age, BW and type I ROP. Previous studies have associated multiple comorbidities, such as RDS, blood transfusion, dysplasia, large patent ductus arteriosus and septic shock have been associated with ROP;[13,15,16] however, in this study, malnutrition ($p < 0.001$), RDS ($p < 0.001$), anemia of prematurity ($p < 0.01$), blood transfusion ($p < 0.05$) and PIH ($p < 0.05$) were associated with ROP. Across different studies,[15,16] RDS was the most common comorbidity which was associated with ROP. Studies indicate that disruption of gas exchange leads to multiple complications including increased risk of ROP in preterm infants.[17] Studies state that parenteral nutrition consisting of high energy and protein, and mother's milk to ensure optimal growth and adiposity in the postnatal weeks may have a protective effect against the development of ROP in preterm infants.[18,19] Likewise, anemia and blood transfusion has been reported as an independent risk factor of ROP in premature infants.[20] On the contrary, in the literature, the effect of maternal PIH on the occurrence of ROP is not conclusive and requires further analysis.[21] Overall, based on the present findings, it can be inferred that multiple neonatal risk factors are associated with the development of ROP and effort should be made to control these factors to reduce the risk of ROP.

In various cohorts, the sensitivity and specificity of WINROP to predict ROP has varied. In the present study, the sensitivity to predict type I ROP through WINROP was low (63.6%) compared with previous studies from countries, such as Saudi (100%),[14] Sweden (100%),[22] and Malaysia (95.2%)[13] which reported high sensitivity but comparable to previous studies from Taiwan (64.7%)[10] and South Africa (72.9%).[5] Further, the specificity of WINROP was low (53.6%) but comparable to previous studies in the literature from Malaysia (33.8%)[13] and Japan (42.7%).[23] A very few Indian studies have used the WINROP algorithm for the prediction of ROP in preterm infants.[8,15] The use of the WINROP model in Indian cohorts has reported sensitivity of 90.3%[8] and 80%,[15] and specificity of 38.4%[8] and 80.6%.[15] Further, the other validation parameter, such as PPV of 42.4% and NPV of 73.3% was comparatively lower with the values mentioned in the Indian setup. In our study, 42% (14/33) of infants with WINROP alarm developed type I ROP and remaining 57% non-type I ROP suggestive of timely testing for the progression of ROP. Based on the given validation parameters of WINROP algorithm, it can be inferred that in infants with WINROP alarm, there is a requirement of ROP screening, and this could reduce the number of unnecessary screenings in preterm infants.

The present study is the inclusion of twin neonates and this is the first study from Indian babies using the WINROP model to predict ROP in twin neonates. Multiple studies have reported association of multiple gestations/twins or multiplets with the risk of ROP.[1] Of the two dichotomous variables, namely, BW and GA which is used in WINROP algorithm,[7] twin babies have the same GA and perinatal risk factors. Thus, they provide a good model to analyze if BW has a role in the progression of ROP.[24] Focused on that, the present study tested the efficacy of the WINROP model to predict ROP in twin neonates. In the present study, in twin babies, WINROP alarm was associated with very low BW ($p < 0.05$) and ROP was significantly associated with comorbidities including malnutrition ($p < 0.001$), RDS ($p < 0.001$), anemia ($p < 0.05$) and PIH ($p < 0.05$); however, further research is required to ascertain the associated factors in twin neonates with ROP. Previous studies have reported higher risk of ROP in discordant twins with lower BWs;[25] however, Azad et al.[24] states that the BW as a factor to screen ROP in twins should be performed with caution. The authors state that presentation and progression of ROP can vary in twins as heavier siblings were also presented with severe ROP. On the contrary, Sanghi et al.[26] reported that birth order, BW, and post-gestational neonatal risk factors do not predict the severity of ROP in twins. Furthermore, the WINROP model predicted type I ROP in twin babies with a high sensitivity of 100% and NPV value of 100% in this study. As stated by Sanghi et al.[8] NPV of 100% presents an ideal situation which can reduce the ROP screening for infants with no alarm. In support of this, Raffa et al.[14] argues that since prediction of ROP is important to prevent blindness, sensitivity and NPV are more relevant than other parameters to screen preterm infants with ROP.

The differences in parameters from the previous studies could be multifactorial including the study design, preterm study population, types of ROP, screening criteria for ROP, provisions for perinatal and postnatal care.[14,15] For instance, studies from Indian clinical settings, such as Sute et al.[15] performed a prospective observational study on 102 singleton preterm infants, whereas our study was retrospective in nature with 63 preterm infants including 12 twin neonates; hence, discrepancies in data within the same geographical settings cannot be avoided. Nevertheless, Ko et al.[10] states that WINROP is an effective tool to predict ROP in infants that meet the criteria of BW and GA of less than 1,000 gm and less than 28 weeks, respectively. However, for infants from developing country such as Asian preterm infant population, the ROP epidemiology and weight gain curve can differ from the developed country; the development of individualized algorithm for different geographical zones is recommended.[10] Based on the present findings that WINROP alarm was signaled in non-type I ROP also, thus, it is recommended to monitor for the progression of non-type I ROP to type I ROP. In addition, considering the small size of population of twin neonates, further validation studies to precisely estimate the sensitivity and specificity of WINROP algorithm and the generalizability of findings on a larger population of twin neonate is suggested.

The study is limited by retrospective design, small sample size and from a single center. Further studies should include prospective design on a larger infant population including twin neonates and from multicenter. Additionally, to improve the predictive efficacy of the algorithm, WINROP model should be modified to accommodate populations with different characteristics such as larger and older babies, and additionally multiple postnatal risk factors should be incorporated.

Conclusion

Overall, the WINROP model had a moderate sensitivity of 63.6%, low specificity of 53.6%, low PPV of 42.4% and high NPV of 73.3% to predict type I ROP. Further, WINROP had a high sensitivity of 100%, a high NPV of 100% but low specificity of 60% and low PPV of 33% to predict type I ROP in twin neonates. Based on these performance parameters, it is suggested that WINROP algorithm be used potentially as an accessory tool and standard ROP screening be performed alongside on infants with WINROP alarm.

References

1. Kim SJ, Port AD, Swan R, et al. Retinopathy of prematurity: A review of risk factors and their clinical significance. Surv Ophthalmol [Internet]. 2018;63(5):618–637. DOI: 10.1016/j.survophthal.2018.04.002.
2. Hartnett ME. Pathophysiology and mechanisms of severe retinopathy of prematurity. Ophthalmology 2015;122(1):200–210. DOI: 10.1016/j.ophtha.2014.07.050.
3. Shukla R, Murthy GVS, Gilbert C, et al. Operational guidelines for ROP in India: A summary. Indian J Ophthalmol 2020;68(Suppl 1):S108–S114. DOI: 10.4103/ijo.IJO_1827_19.
4. Sun H, Kang W, Cheng X, et al. The use of the WINROP screening algorithm for the prediction of retinopathy of prematurity in a Chinese population. Neonatology 2013;104(2):127–132. DOI: 10.1159/000351297.
5. Kesting SJ, Nakwa FL. Prediction of retinopathy of prematurity using the winrop (weight, IGF-1, neonatal retinopathy of prematurity) algorithm in a South African Population. Front Pediatr 2022;10:812404. DOI: 10.3389/fped.2022.812404.
6. Desai S, Athikarisamy SE, Lundgren P, et al. Validation of WINROP (online prediction model) to identify severe retinopathy of prematurity (ROP) in an Australian preterm population: A retrospective study. Eye [Internet] 2021;35(5):1334–1339. DOI: 10.1038/s41433-020-1094-7.
7. Binenbaum G. Algorithms for the prediction of retinopathy of prematurity based on postnatal weight gain. Clin Perinatol 2013;40(2):261–270. DOI: 10.1016/j.clp.2013.02.004.
8. Sanghi G, Narang A, Narula S, et al. WINROP algorithm for prediction of sight threatening retinopathy of prematurity: Initial experience in Indian preterm infants. Indian J Ophthalmol 2018;66(1):110–113. DOI: 10.4103/ijo.IJO_486_17.
9. Thomas D, Madathil S, Thukral A, et al. Diagnostic accuracy of WINROP, CHOP-ROP and ROPScore in detecting type 1 retinopathy of Prematurity. Indian Pediatr 2021;58(10):915–921. DOI: 10.1007/s13312-021-2321-4.
10. Ko C, Kuo H, Chen C, et al. Using WINROP as an adjuvant screening tool for retinopathy of prematurity in southern Taiwan. Am J Perinatol 2015;30(2):149–154. DOI: 10.1055/s-0034-1376389.
11. Yau GS, Lee JW, Tam VT, et al. Incidence and risk factors of retinopathy of prematurity from 2 neonatal intensive care units in a Hong Kong Chinese Population. Asia Pac J Ophthalmol (Phila) 2016;5(3):185–191. DOI: 10.1097/APO.0000000000000167.
12. Li ML, Hsu SM, Chang YS, et al. Retinopathy of prematurity in southern Taiwan: A 10-year tertiary medical center study. J Formos Med Assoc 2013;112(8):445–453. DOI: 10.1016/j.jfma.2012.03.002.
13. Lim ZD, Oo KT, Tai ELM, et al. Efficacy of WINROP as a screening tool for retinopathy of prematurity in the East Coast of Malaysia. Clin Ophthalmol 2020;14:1101–1106. DOI: 10.2147/OPTH.S247820.
14. Raffa LH, Alessa SK, Alamri AS, et al. Prediction of retinopathy of prematurity using the screening algorithm WINROP in a Saudi cohort of preterm infants. Saudi Med J 2020;41(6):622–627. DOI: 10.15537/smj.2020.6.25127.
15. Sute SS, Jain S, Chawla D, et al. Special focus on uvea and retina, original article use of an online screening algorithm – Weight, Insulin – derived growth factor 1, Neonatal Retinopathy of Prematurity (WINROP) for predicting retinopathy of prematurity in Indian preterm babies. Indian J Ophthalmol 2021;69(5):1214–1218. DOI: 10.4103/ijo.IJO_1521_20.
16. Noor MS, Elbarbary M, Embabi SN, et al. Screening and Risk Factors for Retinopathy of Prematurity in a Tertiary Care Hospital in Cairo. Clin Ophthalmol 2022;16:3257–3267. DOI: 10.2147/OPTH.S383493.
17. Lin Y, Chen S, Muo C. Risk of retinopathy of prematurity in preterm births with respiratory distress syndrome: A population-based cohort study in Taiwan. Int J Gen Med 2022;15:2149–2162. DOI: 10.2147/IJGM.S344056.
18. Ingolfsland EC, Haapala JL, Buckley LA, et al. Late growth and changes in body composition influence odds of developing retinopathy of prematurity among preterm infants. Nutrients 2019;12(1):78. Published 2019 Dec 27. DOI: 10.3390/nu12010078.
19. Klevebro S, Westin V, Sjöström E, et al. Early energy and protein intakes and associations with growth, BPD, and ROP in extremely preterm infants. Clin Nutr 2019;38(3):1289–1295. DOI: 10.1016/j.clnu.2018.05.012.
20. Pai HS, Joy R, Cherian V, et al. Anemia in relation to severity of retinopathy of prematurity in preterm babies born in tertiary care centre in South India. Int J Contemp Pediatr 2020;7(10):2005–2009. DOI: 10.18203/2349-3291.ijcp20204043.
21. Ge G, Zhang Y, Zhang M. Pregnancy-induced hypertension and retinopathy of prematurity: A meta-analysis. Acta Ophthalmol 2021;99(8):e1263–e1273. DOI: 10.1111/aos.14827.
22. Löfqvist C, Hansen-pupp I, Andersson E, et al. Validation of a new retinopathy of prematurity screening method monitoring longitudinal postnatal weight and insulin like growth factor I. Arch Ophthalmol 2009;127(5):622–627. DOI: 10.1001/archophthalmol.2009.69.
23. Ueda K, Miki A, Nakai S, et al. Prediction of severe retinopathy of prematurity using the weight gain, insulin-like growth factor 1, and neonatal retinopathy of prematurity algorithm in a Japanese population of preterm infants. Japanese J Ophthalmol 2020;64(2):223–227. DOI: 10.1007/s10384-019-00709-z.
24. Azad R, Chandra P, Patwardhan SD, et al. Profile of asymmetrical retinopathy of prematurity in twins. Indian J Ophthalmol 2010;58(3):209–211. DOI: 10.4103/0301-4738.62645.
25. Petriçli İS, Kara C, Işık DU, et al. Effect of birth weight on retinopathy of prematurity in discordant twin pairs. Indian J Ophthalmol 2019;67(6):806–810. DOI: 10.4103/ijo.IJO_1197_17.
26. Sanghi G, Dogra MR, Dutta S, et al. Intersibling variability of retinopathy of prematurity in twins and its risk factors. Int Ophthalmol 2012;32(2):113–117.