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Incidence and risk factors of intraprocedural hypoxia during bedside intravitreal ranibizumab injection for retinopathy of prematurity: a multicenter retrospective study

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Incidence and risk factors of intraprocedural hypoxia during bedside intravitreal ranibizumab injection for retinopathy of prematurity: a multicenter retrospective study

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Abstract

Background

Intravitreal anti-vascular endothelial growth factor (anti-VEGF) therapy has become an established treatment for type 1 retinopathy of prematurity (ROP). However, evidence regarding intraprocedural hypoxia during bedside intravitreal injection remains limited. This study evaluated the incidence, severity, and predictors of hypoxia during intravitreal ranibizumab injection for treatment-requiring ROP.

Methods

This retrospective multicenter observational study included premature infants with treatment-requiring ROP who underwent bedside intravitreal ranibizumab injection under topical anesthesia between July 2020 and June 2026 in neonatal intensive care units across the Al Qassim region, Saudi Arabia. Continuous pulse oximetry was used during the procedure and for 30 minutes afterward. Hypoxia was classified as mild (oxygen saturation 85–89%), moderate (80–84%), or severe (<80%). Demographic, perinatal, maternal, and ophthalmic variables were analyzed. Logistic regression was performed to identify factors associated with hypoxia.

Results

Seventy-four premature infants out of 1430 were included. The mean gestational age was 27.5 ± 2.2 weeks, the mean birth weight was 986.8 ± 265.8 g, and the mean postmenstrual age at treatment was 36.6 ± 2.2 weeks. Hypoxia occurred in 12 infants (16.2%; 95% CI, 8.7–26.6%), including 10 (13.5%) with mild hypoxia and 2 (2.7%) with moderate hypoxia; no episodes of severe hypoxia were observed. Lower gestational age (OR 0.51, 95% CI 0.35–0.76; $P = 0.001$), lower birth weight (OR 0.991 per gram increase, 95% CI 0.984–0.997; $P = 0.004$), and longer duration of oxygen therapy (OR 1.35, 95% CI 1.03–1.77; $P = 0.028$) were associated with hypoxia in univariate analysis. After adjustment, birth weight remained the principal predictor of increasing hypoxia severity. At follow-up, regression of ROP was achieved in 60 infants (81.1%), while 4 (5.4%) required repeat ranibizumab injection and 10 (13.5%) underwent adjunctive laser photocoagulation.

Conclusions

Bedside intravitreal ranibizumab injection under topical anesthesia was associated with a low incidence of transient hypoxia, and no severe oxygen desaturation events occurred. Lower birth

weight and lower gestational age were associated with an increased risk of hypoxia. These findings support the short-term cardiorespiratory safety of bedside ranibizumab injection in premature infants while emphasizing the importance of continuous physiological monitoring, particularly in extremely low-birth-weight infants.

Keywords: Retinopathy of prematurity; Ranibizumab; Intravitreal injection; Hypoxia; Oxygen desaturation; Neonatal intensive care unit.

Introduction

Retinopathy of prematurity (ROP) is a vasoproliferative retinal disorder affecting premature infants and remains one of the leading preventable causes of childhood blindness worldwide [1–4]. Advances in neonatal intensive care have markedly improved the survival of extremely premature and very-low-birth-weight infants, resulting in an increasing number of neonates at risk for developing treatment-requiring ROP. Although the incidence of ROP varies considerably among countries because of differences in neonatal care, screening practices, and survival rates, severe ROP continues to represent an important cause of lifelong visual impairment when timely treatment is not provided [5 –12].

Low gestational age and low birth weight are the principal risk factors for the development of ROP [13 –14]. Additional maternal and perinatal factors, including hypertensive disorders of pregnancy, diabetes mellitus, premature rupture of membranes, multiple gestation, assisted reproductive technologies, and neonatal respiratory morbidity, have also been implicated in disease development. Recognition of these risk factors has improved screening strategies and facilitated earlier identification of infants requiring treatment [15 –17].

Laser photocoagulation has historically been the standard treatment for type 1 ROP by ablating the peripheral avascular retina and reducing angiogenic drive [18 –19]. However, laser therapy is associated with permanent destruction of peripheral retina, visual field constriction, and the development of high myopia. Over the past decade, intravitreal anti-vascular endothelial growth factor (anti-VEGF) therapy has become an established alternative, particularly for aggressive posterior ROP and zone I disease. Ranibizumab has attracted increasing attention because of its shorter systemic half-life and lower systemic suppression of vascular endothelial growth factor compared with bevacizumab, potentially reducing systemic exposure in premature infants while maintaining favorable anatomical outcomes [20 –22].

Despite the widespread adoption of intravitreal anti-VEGF therapy, premature infants remain physiologically vulnerable during ophthalmic procedures. Manipulation of the eyelids and globe, placement of an eyelid speculum, and procedural stress may trigger transient cardiorespiratory instability, including oxygen desaturation, apnea, or bradycardia, even when injections are performed under topical anesthesia [23-24]. Although topical anesthesia avoids the risks associated with general anesthesia or deep sedation, it does not eliminate procedure-related physiological stress. Therefore, continuous cardiorespiratory monitoring during bedside intravitreal injection remains an essential component of patient safety.

Previous studies [25 –30] have primarily focused on the efficacy, recurrence rates, and long-term ocular outcomes of anti-VEGF therapy for ROP, whereas evidence regarding intraprocedural physiological instability during intravitreal injection remains limited. Most available reports have evaluated cardiorespiratory events during ROP screening examinations rather than during anti-VEGF treatment itself, and data from neonatal intensive care units in the Middle East are scarce. Consequently, the incidence, severity, and determinants of hypoxia during bedside intravitreal ranibizumab injection have not been adequately characterized.

Therefore, the present study aimed to determine the incidence and severity of intraprocedural hypoxia during bedside intravitreal ranibizumab injection for treatment-requiring ROP and to identify neonatal and maternal factors associated with hypoxic events in a multicenter cohort of premature infants treated in neonatal intensive care units across the Al Qassim region of Saudi Arabia.

Materials and Methods

Study design and setting

This multicenter retrospective observational study included premature infants with treatment-requiring retinopathy of prematurity (ROP) who underwent bedside intravitreal ranibizumab injection at neonatal intensive care units (NICUs) across multiple hospitals in the Al Qassim region, Saudi Arabia, between July 2020 and June 2026. The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the institutional Research Ethics Committee before data collection commenced as well as a written informed consent for publication was obtained from the parents or legal guardians of the participants. Clinical and demographic data were retrospectively extracted from electronic medical records using a standardized data collection form. Information was independently verified before statistical analysis to ensure data completeness and accuracy.

Study population

Premature infants diagnosed with treatment-requiring ROP and treated with intravitreal ranibizumab during the study period were eligible for inclusion.

Inclusion criteria

- Premature infants with treatment-requiring ROP.
- Treatment with intravitreal ranibizumab.
- Complete procedural monitoring records, including continuous pulse oximetry.
- Availability of follow-up data after treatment.

Exclusion criteria

Infants were excluded if they had:

- Incomplete procedural or follow-up data.
- Major congenital anomalies affecting cardiorespiratory function.
- Bronchopulmonary dysplasia.
- Intraventricular hemorrhage.
- Patent ductus arteriosus.
- Respiratory distress syndrome requiring surfactant therapy.

These exclusion criteria were applied to minimize confounding factors that could independently influence oxygen saturation during the procedure.

Data collection

The following variables were collected from medical records:

- Neonatal characteristics:
    - Sex
    - Gestational age
    - Birth weight
    - Postmenstrual age at injection
    - Duration of supplemental oxygen therapy
    - Respiratory status
    - Presence of congenital anomalies
- Maternal characteristics:
    - Maternal age
    - Hypertensive disorders during pregnancy
    - Diabetes mellitus
    - Premature rupture of membranes
    - Prenatal infection
    - Twin pregnancy
    - Parental consanguinity
- Ophthalmic characteristics:
    - ROP zone
    - ROP stage
    - Presence of plus disease
    - Laterality
    - Injection sequence
    - Follow-up outcome
    - Ocular complications

Injection procedure

All intravitreal injections were performed at the bedside in the NICU by the same experienced vitreoretinal surgeon using a standardized injection protocol based on the SAFER-ROP recommendations [31].

Topical anesthesia was achieved using topical anesthetic eye drops before the procedure. After ocular surface disinfection with 5% povidone-iodine, intravitreal ranibizumab (0.25 mg/0.025 mL) was injected through the pars plicata using a 32-gauge, 4-mm needle positioned approximately 0.75–1.0 mm posterior to the limbus under sterile conditions.

All infants remained under continuous pulse oximetry monitoring throughout the procedure and for at least 30 minutes following injection. Standard neonatal supportive measures and resuscitation equipment were immediately available whenever required.

Outcome measures

Primary outcome

The primary outcome was the occurrence of intraprocedural hypoxia during or within 30 minutes after intravitreal ranibizumab injection.

Hypoxia was classified according to peripheral oxygen saturation measured by continuous pulse oximetry:

- No hypoxia: ≥90%
- Mild hypoxia: 85–89%
- Moderate hypoxia: 80–84%
- Severe hypoxia: <80%

Whenever oxygen desaturation occurred, the need for clinical intervention was documented.

Secondary outcomes

Secondary outcomes included:

- Requirement for procedural intervention
- Regression of ROP
- Repeat intravitreal ranibizumab injection
- Adjunctive laser photocoagulation
- Procedure-related ocular complications during follow-up

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for normality and are presented as mean ± standard deviation (SD) or median (interquartile range), as appropriate. Categorical variables are presented as frequencies and percentages. Comparisons between infants with and without hypoxia were performed using the independent-samples *t* test for normally distributed continuous variables and the χ^2 test or Fisher's exact test for categorical variables. Spearman's rank correlation coefficient was used to evaluate associations between hypoxia and selected clinical variables. Univariate logistic regression analysis was performed to identify factors associated with the occurrence of

hypoxia. Variables considered clinically relevant or demonstrating significant associations in univariate analyses were entered into multivariable logistic regression models to evaluate independent predictors of hypoxia. Ordinal logistic regression analysis was additionally performed to investigate factors associated with increasing hypoxia severity (none, mild, moderate, and severe). Model assumptions, including the proportional odds assumption, were assessed before interpretation of the results. Odds ratios (ORs) with 95% confidence intervals (CIs) are reported. All statistical tests were two-sided, and a P value <0.05 was considered statistically significant.

Results

Patient characteristics

A total of 74 premature infants with treatment-requiring ROP were included in the study. Of these, 40 (54.1%) were male and 34 (45.9%) were female. The mean gestational age was 27.5 ± 2.2 weeks, the mean birth weight was 986.8 ± 265.8 g, and the mean postmenstrual age at the time of intravitreal ranibizumab injection was 36.6 ± 2.2 weeks. The mean age at ROP diagnosis was 35.3 ± 1.8 weeks, while the mean duration of supplemental oxygen therapy was 8.8 ± 2.0 weeks **(Table 1).**

Incidence and severity of hypoxia

Intraprocedural hypoxia occurred in 12 of 74 infants (16.2%; 95% CI, 8.7%–26.6%), whereas 62 infants (83.8%) maintained oxygen saturation ≥90% throughout the monitoring period. Mild hypoxia (oxygen saturation 85–89%) occurred in 10 infants (13.5%), while 2 infants (2.7%) experienced moderate hypoxia (80–84%). No episodes of severe hypoxia (<80%) were recorded **(Table 2; Figure 1).** Procedural intervention was required in 3 infants (4.1%), all of whom recovered without permanent sequelae.

Ophthalmic characteristics

Zone II ROP was present in 58 infants (78.4%), whereas 16 infants (21.6%) had Zone I disease. Stage 3 ROP was identified in 73 infants (98.6%), with one infant (1.4%) presenting with Stage 2 disease. Plus disease was present in all treated eyes. Bilateral intravitreal ranibizumab injection was performed in 63 infants (85.1%), while unilateral treatment was performed in 11 infants (14.9%) **(Table 3)**.

Factors associated with hypoxia

Infants who developed hypoxia had significantly lower gestational age and birth weight than those without hypoxia. Gestational age demonstrated a moderate negative correlation with hypoxia (Spearman's $\rho = -0.429$, $P < 0.001$), while birth weight also showed a significant negative correlation (Spearman's $\rho = -0.443$, $P < 0.001$). Maternal age, laterality, and postmenstrual age at treatment were not significantly associated with hypoxia **(Table 4).**

When infants were stratified according to hypoxia status, those with hypoxia had significantly lower mean gestational age (25.6 ± 1.4 vs. 27.9 ± 2.1 weeks, P = 0.001) and lower birth weight (748.8 ± 100.0 vs. 1032.9 ± 263.5 g, P < 0.001) than infants without hypoxia. Duration of oxygen therapy showed a borderline association with hypoxia (P = 0.057). No statistically significant differences were observed regarding maternal age, postmenstrual age at treatment, maternal hypertension, maternal diabetes, premature rupture of membranes, prenatal infection, twin pregnancy, or laterality **(Table 5).**

Logistic regression analysis

In univariate logistic regression analysis, lower gestational age was significantly associated with hypoxia (OR, 0.51; 95% CI, 0.35–0.76; P = 0.001). Lower birth weight was similarly associated with increased hypoxia risk (OR, 0.991 per gram increase; 95% CI, 0.984–0.997; P = 0.004). Longer duration of oxygen therapy was also associated with hypoxia (OR, 1.35; 95% CI, 1.03–1.77; P = 0.028), whereas postmenstrual age at treatment, maternal age, and ROP onset were not significantly associated with the outcome **(Table 6).**

Ordinal logistic regression demonstrated that lower gestational age, lower birth weight, and longer oxygen therapy were associated with increasing hypoxia severity in univariate analyses. After multivariable adjustment **(Table 7),** birth weight remained the only independent predictor of increasing hypoxia severity (adjusted OR, 0.992; 95% CI, 0.984–1.000; P = 0.039). No independent associations were identified for gestational age, maternal age, duration of oxygen therapy, sex or consanguinity. The proportional odds assumption was satisfied, indicating an acceptable model fit. Because only 12 hypoxic events occurred, the multivariable logistic regression model should be interpreted cautiously. Regression estimates may have been influenced by sparse-event bias, although birth weight remained the strongest predictor after adjustment.

Follow-up outcomes

During follow-up, regression of ROP was achieved in 60 infants (81.1%). Repeated intravitreal ranibizumab injection was required in 4 infants (5.4%), while 10 infants (13.5%) underwent adjunctive laser photocoagulation because of persistent or recurrent disease **(Figure 2).**

Ocular complications

As shown in **(Table 8),** no ocular complications occurred in 55 infants (74.3%). The most common complication was ROP reactivation or progression, observed in 8 infants (10.8%). Other complications included peripheral retinal avascularity in 3 infants (4.1%), myopia in 2 infants (2.7%), tractional retinal detachment requiring pars plana vitrectomy in 2 infants (2.7%), and cataract in 1 infant (1.4%).

In summary, study flow diagram was shown in (**Figure 3).**

Discussion

The present multicenter retrospective study evaluated the incidence, severity, and predictors of intraprocedural hypoxia during bedside intravitreal ranibizumab injection for treatment-requiring retinopathy of prematurity (ROP). Hypoxia occurred in 16.2% of infants, with most episodes being mild and transient, while no episodes of severe oxygen desaturation were observed. Lower gestational age, lower birth weight, and prolonged oxygen therapy were associated with hypoxia in univariate analyses, whereas birth weight remained the principal independent predictor of increasing hypoxia severity. These findings support the short-term cardiorespiratory safety of bedside intravitreal ranibizumab injection when performed under continuous physiological monitoring.

Although anti-VEGF therapy has become an established treatment for type 1 ROP, relatively little attention has been directed toward physiological instability occurring during the injection procedure itself. Most published studies have focused on anatomical regression, recurrence rates, refractive outcomes, systemic VEGF suppression, or long-term neurodevelopmental outcomes [32 –33]. In contrast, data specifically addressing intraprocedural oxygen desaturation remain limited, particularly in NICU settings. Our study therefore contributes clinically relevant information by quantifying the frequency and severity of hypoxia during bedside ranibizumab administration in a multicenter cohort.

The observed hypoxia rate of 16.2% falls within the range of cardiorespiratory events reported during ROP screening examinations. Direct comparison with previous studies should be made cautiously because most published reports evaluated retinal examinations rather than intravitreal anti-VEGF injections [34 –37]. Nevertheless, the absence of severe hypoxia and the low proportion of infants requiring clinical intervention suggest that intravitreal ranibizumab is generally well tolerated from a cardiorespiratory standpoint when appropriate neonatal monitoring is maintained.

One of the principal findings of this study was the association between lower gestational age and an increased risk of hypoxia. Premature infants born at earlier gestational ages have immature respiratory control mechanisms, reduced pulmonary reserve, and diminished autonomic stability, making them more susceptible to oxygen desaturation during stressful procedures. These physiological characteristics provide a plausible explanation for the increased vulnerability observed in our cohort and are consistent with previous neonatal studies evaluating procedural cardiorespiratory instability [38 –39].

Birth weight demonstrated an even stronger relationship with hypoxia than gestational age and remained the only independent predictor of increasing hypoxia severity after multivariable adjustment. Birth weight likely reflects the combined effects of prematurity, fetal growth, and physiological reserve. Infants with extremely low birth weight have limited cardiopulmonary reserve and reduced tolerance to procedural stress, predisposing them to transient oxygen desaturation during ophthalmic interventions. From a clinical perspective, these findings suggest that birth weight may be a practical parameter for identifying infants who require closer physiological monitoring during anti-VEGF treatment.

Although longer duration of oxygen therapy was associated with hypoxia in univariate analysis, this association was no longer significant after adjustment for other neonatal variables. This finding suggests that prolonged oxygen supplementation is more likely a marker of underlying respiratory immaturity than an independent determinant of procedural hypoxia. Similarly, maternal age, maternal medical conditions, twin pregnancy, and treatment laterality were not independently associated with hypoxic events. While consanguinity showed a trend toward increased risk, the wide confidence intervals and lack of statistical significance indicate that this observation should be interpreted cautiously.

The clinical outcomes observed in this study further support the effectiveness of intravitreal ranibizumab for treatment-requiring ROP. More than 80% of infants achieved disease regression following a single injection, whereas only a small proportion required repeat injection or adjunctive laser photocoagulation. In addition, ocular complications were uncommon, and most infants completed follow-up without procedure-related adverse events. These findings are consistent with previous reports demonstrating favorable anatomical outcomes after anti-VEGF therapy [40 –41].

Strengths

This study has several strengths. It is among the few multicenter studies specifically designed to evaluate intraprocedural hypoxia during intravitreal ranibizumab injection in premature infants with ROP. Standardized bedside injection techniques, continuous pulse oximetry monitoring, and comprehensive assessment of neonatal and maternal characteristics enabled a detailed evaluation of factors associated with oxygen desaturation. Furthermore, the multicenter design enhances the generalizability of the findings within similar NICU settings.

Limitations

Several limitations should be acknowledged. First, the retrospective observational design is inherently susceptible to selection bias and incomplete documentation. Second, the relatively small sample size and the limited number of hypoxic events reduced the statistical power of multivariable analyses and may have contributed to unstable regression estimates. Third, the absence of a comparison group treated with laser photocoagulation or an alternative anti-VEGF agent precluded direct comparison of procedural safety between treatment modalities. Finally, only short-term cardiorespiratory outcomes were evaluated; longer-term respiratory, neurological, and developmental outcomes were beyond the scope of this study and warrant investigation in future prospective studies.

Clinical implications

The findings of this study have practical implications for neonatal ophthalmic practice. Although bedside intravitreal ranibizumab injection appears to be associated with a favorable short-term cardiorespiratory safety profile, premature infants particularly those with extremely low birth weight or low gestational age should undergo continuous pulse oximetry monitoring during and immediately after the procedure. Early recognition and prompt management of transient oxygen desaturation may further improve procedural safety in this vulnerable population.

List of Abbreviations

Anti-VEGF: Anti-vascular endothelial growth factor

BPD: Bronchopulmonary dysplasia

CI: Confidence interval

IVH: Intraventricular hemorrhage

NICU: Neonatal intensive care unit

OR: Odds ratio

PDA: Patent ductus arteriosus

PMA: Postmenstrual age

ROP: Retinopathy of prematurity

SD: Standard deviation

VEGF: Vascular endothelial growth factor

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Research Ethics Committee of Qassim University and the participating institutions prior to data collection. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and its subsequent amendments as well as a written informed consent for participation was obtained from the parents or legal guardians of the participants.

Consent for publication

A written informed consent for publication was obtained from the parents or legal guardians of the participants.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request and with approval from the relevant institutional authorities.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Abdulaziz M. Al-Hadlaq contributed to study conception and design, patient recruitment, clinical management, data interpretation, critical revision of the manuscript, and approved the final version.

Waleed M.A. Nagy contributed to study design, patient recruitment, data interpretation, and approved the final version.

Shaaban A.M. Elwan conceived the study, designed the methodology, collected and analyzed the data, performed the statistical analysis, interpreted the findings, drafted the manuscript, critically revised the manuscript for important intellectual content, and approved the final version.

All authors read and approved of the final manuscript.

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Authors' information

Not applicable.

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Table 1. Baseline demographic and clinical characteristics of the study population (n = 74)

Variable	Mean ± SD	Median	Range
Birth weight (g)	986.8 ± 265.8	1100	500–1600
Gestational age (weeks)	27.5 ± 2.2	28	23–32
Postmenstrual age at injection (weeks)	36.6 ± 2.2	36	32–41
Postmenstrual age at ROP diagnosis (weeks)	35.3 ± 1.8	35	32–40
Duration of oxygen therapy (weeks)	8.8 ± 2.0	9	4–13

Abbreviations: SD, standard deviation; ROP, retinopathy of prematurity.

Table 2. Incidence and severity of hypoxia during intravitreal ranibizumab injection

Hypoxia grade	Oxygen saturation (%)	n (%)
No hypoxia	≥90	62 (83.8)
Mild hypoxia	85–89	10 (13.5)
Moderate hypoxia	80–84	2 (2.7)
Severe hypoxia	<80	0 (0.0)

Table 3. Neonatal ophthalmic baseline characteristics

Variable	Total cohort (n = 74)
Neonatal variables	
Male sex	40 (54.1)
Female sex	34 (45.9)
Zone I disease	16 (21.6)
Zone II disease	58 (78.4)
Stage 2 ROP	1 (1.4)
Stage 3 ROP	73 (98.6)
Plus disease	74 (100)
Bilateral treatment	63 (85.1)
Unilateral treatment	11 (14.9)

Table 4. Correlation between hypoxia and clinical variables

Variable	Spearman's ρ	P value
Sex	0.250	0.054
Laterality	0.183	0.118
Birth weight	–0.443	**<0.001**
Gestational age	–0.429	**<0.001**
Postmenstrual age at injection	–0.004	0.959

Table 5. Comparison of infants with and without hypoxia

Variable	No hypoxia (n = 62)	Hypoxia (n = 12)	P value
Birth weight (g)	1032.9 ± 263.5	748.8 ± 100.0	<0.001
Gestational age (weeks)	27.9 ± 2.1	25.6 ± 1.4	0.001
Postmenstrual age at injection (weeks)	36.65 ± 2.25	36.58 ± 2.35	0.959
Duration of oxygen therapy (weeks)	8.9 ± 2.5	10.8 ± 2.9	0.057
Maternal age (years)	30.3 ± 3.2	30.0 ± 3.2	0.988

Footnote: Consanguinity (P = 0.067) and laterality (P = 0.286) were not significantly associated with hypoxia.

Table 6. Univariate logistic regression analysis of factors associated with hypoxia

Variable	Odds ratio	95% CI	P value
Gestational age	0.51	0.35–0.76	0.001
Birth weight	0.991	0.984–0.997	0.004
Duration of oxygen therapy	1.35	1.03–1.77	0.028
Postmenstrual age at injection	0.988	0.748–1.303	0.930
ROP onset	1.024	0.776–1.351	0.869
Maternal age	0.97	0.80–1.19	0.781

Abbreviations: CI, confidence interval; ROP, retinopathy of prematurity.

Table 7. Multivariable logistic regression analysis of factors associated with intraprocedural hypoxia

Variable	Adjusted OR	95% CI	Wald χ^2	P value
Birth weight (per 1 g increase)	0.992	0.984–1.000	4.25	0.039
Gestational age (weeks)	0.887	0.64–1.42	0.06	0.632
Maternal age (years)	1.04	0.81–1.33	0.08	0.758
Duration of oxygen therapy (weeks)	1.14	0.83–1.57	0.64	0.424
Female sex	2.18	0.45–10.52	0.94	0.333
Consanguinity	7.23	0.57–91.97	2.33	0.127
Laterality	—	—	—	Not estimated

Abbreviations: OR, odds ratio; CI, confidence interval.

Footnotes

Laterality could not be reliably estimated because of quasi-complete separation resulting from the small number of hypoxia events.

Table 8. Ocular complications following intravitreal ranibizumab injection

Ocular complication	n (%)	95% CI (%)
No ocular complications	55 (74.3)	62.8–83.9
ROP reactivation/progression	8 (10.8)	4.8–20.2
Peripheral retinal avascularity	3 (4.1)	0.9–11.5
Myopia	2 (2.7)	0.3–9.4
Tractional retinal detachment requiring pars plana vitrectomy	2 (2.7)	0.3–9.4
Cataract	1 (1.4)	0.0–7.3

Footnote

Percentages are based on the total study population (n = 74). Confidence intervals were calculated using the exact (Clopper–Pearson) binomial method because of the small number of events. Most infants experienced no ocular complications during follow-up. The most frequent complication was ROP reactivation, while visually significant complications remained uncommon.

Figures

Figure 1

Incidence and severity of hypoxia during bedside intravitreal ranibizumab injection.

Distribution of hypoxia among 74 premature infants with treatment-requiring retinopathy of prematurity. Most infants (83.8%) maintained oxygen saturation ≥90% throughout the procedure. Mild hypoxia occurred in 13.5% of infants, moderate hypoxia in 2.7%, and no episodes of severe hypoxia were observed.

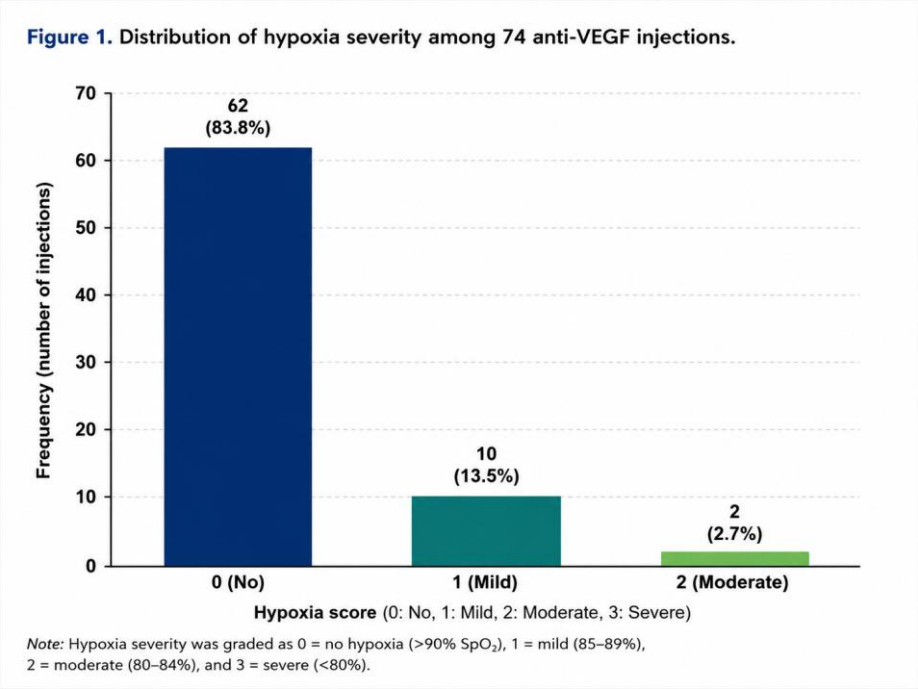


Figure 2

Clinical outcomes during follow-up after intravitreal ranibizumab treatment.

Follow-up outcomes of the study cohort. Regression of retinopathy of prematurity was achieved in 81.1% of infants. Repeat intravitreal ranibizumab injection was required in 5.4%, whereas 13.5% underwent adjunctive laser photocoagulation because of persistent or recurrent disease.

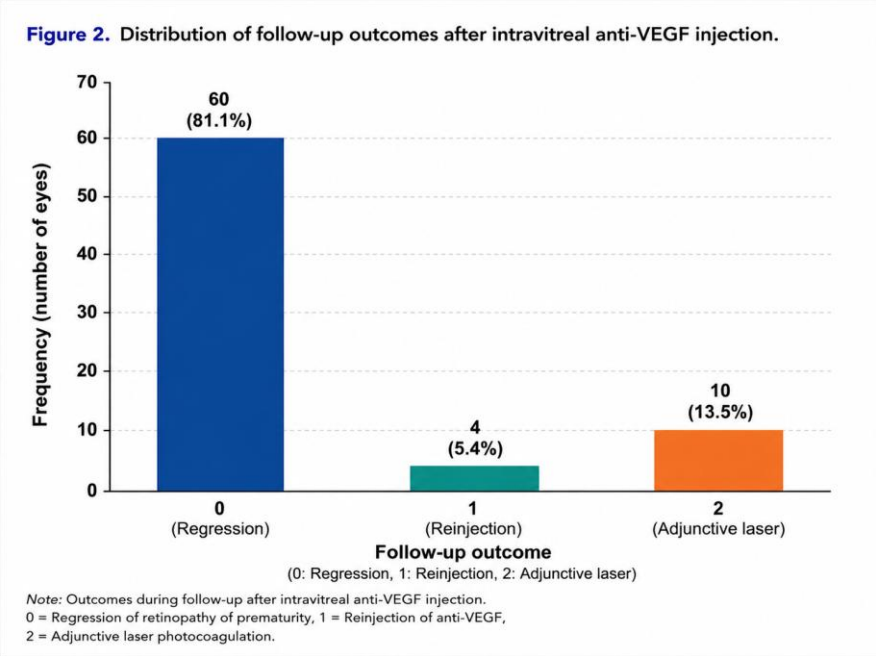


Figure 3. Study flow diagram

