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Long-Term Cost Analysis of Initial Panretinal Photocoagulation for Proliferative Diabetic Retinopathy Performed in the Operating Room vs the Clinic

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Abstract

Purpose: To evaluate a treatment-naïve cohort of patients with proliferative diabetic retinopathy (PDR) and assess the costs of panretinal photocoagulation (PRP) initially performed in the operating room or the clinic, incorporating the cost of the additional follow-up procedures required for each treatment group. **Methods:** A retrospective review was performed of patients with PDR initially treated with PRP in the operating room or the clinic. Cost data were derived from Current Procedural Terminology codes, and estimated mean facility costs were provided. For each cohort, negative binomial regressions were used to compare counts of subsequent interventions, and visual acuity (VA) outcomes and dollars per patient-treatment year were compared with paired *t* tests. **Results:** Eighty-two eyes of 53 patients met the inclusion criteria. The operating room cohort included 56 eyes of 38 patients, while the clinic cohort included 26 eyes of 16 patients. Patients had a minimum follow-up of more than 3 years. The operating room cohort required fewer subsequent PRP treatments (mean, 1.0 vs 2.1; $P < .05$) and surgeries (mean, 0.3 vs 0.7; $P < .05$) than the clinic cohort. The mean best-corrected VA (BCVA) after treatment was significantly better in the operating room cohort (0.30 $\pm$ 0.40 logMAR; Snellen equivalent, 20/39.9) than the clinic cohort (0.75 $\pm$ 0.81 logMAR; Snellen equivalent, 20/112.5) ($P < .05$). The cost per patient-treatment year was similar between the cohorts (operating room, $5,886.79; clinic, $5,657.50) ($P = .75$). **Conclusions:** PRP initially administered in the operating room was equal in cost to clinic administration and required fewer subsequent PRP sessions and surgical treatments. In addition, there was a significant improvement in the final BCVA.

Keywords

cost analysis, panretinal photocoagulation, proliferative diabetic retinopathy

Introduction

Proliferative diabetic retinopathy (PDR) is a major global health concern, affecting approximately 17% to 20% of individuals with diabetes who have DR.[1,2] If left untreated, this advanced stage of disease can lead to severe visual impairment. Its deleterious effects, rooted in neovascularization, can lead to a vitreous hemorrhage, tractional retinal detachment (TRD), and central and peripheral vision loss.[2] Therapeutic interventions, combined with appropriate glucose management, are essential for preserving vision over time in these patients.

Since its introduction in the 1960s, panretinal photocoagulation (PRP) has remained a crucial component of therapy for patients with PDR.[3] Compared with laser therapy alone, combination therapy with antivascular endothelial growth factor (anti-VEGF) has led to improved outcomes.[4] Systematic reviews and meta-analyses have further validated the effectiveness of coupling PRP with anti-VEGF injections, finding that this results in greater improvements in visual acuity (VA) and decreased neovascularization compared with PRP alone and has an acceptable safety profile without additional adverse events.[5,6] Moreover, significant findings from Protocol S have shifted the treatment paradigm, showing that anti-VEGF can be used in the absence of PRP to treat PDR.[7] However, this is controversial in clinical practice because some studies have shown poor outcomes in patients treated with anti-VEGF alone who

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are lost to follow-up.[8–10] This is a critical insight for determining the cost-effectiveness and clinical outcomes of different treatment modalities in real-world settings.

Although anti-VEGF treatments such as bevacizumab, ranibizumab, and aflibercept have shown efficacy in treating DR, their long-term administration relies on regular clinic visits, which poses a potential challenge for patients with difficult socioeconomic, medical, and personal circumstances.[4] When performed thoroughly, PRP offers an initial therapy with a longer-lasting benefit. Many providers offer PRP in a clinic or operating room setting. In a previous study, our group found that fewer subsequent surgical and laser interventions were required after initial therapy in the operating room than in the clinic.[11] Multiple studies have explored the cost implications of these settings, showing that in general, procedures performed in the clinic are less costly than those done in the operating room. The need for anesthesia is reduced, fewer staff are required, and procedure times are shorter, leading to substantial cost savings and improved efficiency.[12,13]

Specifically, cost analyses performed for a variety of medical procedures support the idea that not only are direct costs significantly reduced, but the efficiency of the healthcare delivery process is improved as well.[14] This has been shown in studies across various specialties, indicating that clinic-based procedures can offer substantial savings over those performed in operating rooms.[15–19] These findings align with broader healthcare trends emphasizing cost reduction and efficiency enhancement without compromising patient outcomes. As the healthcare landscape continues to evolve, understanding the cost dynamics of various treatment settings is crucial for healthcare professionals and policymakers aiming to optimize healthcare delivery while maintaining high standards of patient care.

This study assessed the costs of initial PRP performed in the operating room and compared it with the costs of PRP performed in the clinic, incorporating the cost of additional follow-up procedures required for each treatment cohort.

Methods

This retrospective chart review comprised a previously studied treatment-naïve cohort of patients who had PRP between January 1, 2016, and December 31, 2020, with the purpose of incorporating a cost analysis of the initial treatment of PDR performed in the operating room vs in the clinic. This research complied with the Declaration of Helsinki and was approved by the University of Alabama at Birmingham Institutional Review Board. Exclusion criteria were a previous history of PRP, concomitant pars plana vitrectomy (PPV), a documented plan for sequential treatments of PRP, a history of PRP performed in both settings (ie, operating room and clinic), and a follow-up of less than 3 years to April 1, 2024, when the study concluded. Previous intravitreal (IVT) anti-VEGF therapy was not an exclusion criterion.

Patients' demographic data were obtained from medical records at Retina Consultants of Alabama and included age, sex, ocular history (surgery and comorbidities), insulin dependence, most recent glycosylated hemoglobin (HbA_{1c}), and preoperative symptoms.

Cost data for the patient's initial treatment and subsequent procedures were collected from Current Procedural Terminology (CPT) codes listed in the surgical documentation. All initial PRPs were coded 67228 with or without concomitant anti-VEGF IVT injection (CPT code 67028). Follow-up interventions throughout the patient's therapeutic course were collected in the same fashion. Table 1 shows the procedure and clinic appointment cost data. The IVT anti-VEGF agents included bevacizumab and aflibercept, with equivalent procedural cost. Injections administered after laser treatment in the operating room and in the clinic were given to control PDR and coexisting diabetic macular edema (DME), if present.

For additional facility costs, the average cost of running the operating room for each surgical intervention was provided by the chief financial officer at the institution and incorporated into the cost data. Analysis was based on the cumulative cost of initial treatment and subsequent interventions over the length of follow-up for each patient, represented in dollars per patient-year of treatment. Further details can be found in a previous study.[11]

Counts of subsequent surgeries involving PPVs, PRP treatments, focal laser treatments, and injections were obtained through chart review, as was the best-corrected VA (BCVA) before and after the procedure, obtained using Snellen VA charts. Snellen measurements were then converted to logMAR values for analysis using the model outlined by Tiew et al.[20] Statistical analysis of the data was performed with R software (R Project for Statistical Computing) using descriptive statistics for follow-up time, demographics, subsequent interventions, and VA measurements. Negative binomial regressions were used to compare subsequent interventions between the groups. Paired *t* tests were used to determine the statistical significance of the change in VA after treatment in the cohorts, and a cost analysis was performed. Statistical significance was set at $P \leq .05$. Mean values are ± SD.

Results

Eighty-two eyes of 53 patients met the study's inclusion criteria. Of these 82 eyes, 45 (54.9%) were of women and 37 (71.1%) were of men. The mean age of the patients was 52 ± 13.7 years (range, 24-81).

Fifty-six eyes (68.3%) of 38 patients had initial PRP performed in the operating room, and 26 (31.7%) eyes of 16 patients had initial PRP performed in the clinic. One patient qualified for both cohorts, with 1 eye receiving initial therapy in the operating room and the other eye treated in the clinic. The mean follow-up was 53.6 ± 9.7 months (range, 38-75) for both cohorts, with no statistical difference between them.

Table 2 shows the mean age, mean follow-up, percentage of patients requiring insulin therapy, mean HbA_{1c}, and preoperative VA measurements in logMAR units. There was no statistically significant difference in these variables between the cohorts. A higher percentage of patients in the clinic cohort than patients in the operating room cohort had both eyes treated with PRP in the clinic (62.5% vs 47.4%). However, this difference was not statistically significant ($P = .31$, χ^2 test).

Table 3 shows a comparison of subsequent interventions and the total cost by initial treatment location. With the addition of

Table 1. Procedure Cost Based on CPT Code.

CPT Code	Procedure	Cost
67028	Intravitreal injection	$300
67210	Destruction of localized lesion of retina; photocoagulation	$1,170
67228	Panretinal photocoagulation	$1,170
67036	Vitrectomy, pars plana approach	$2,300
67040	Vitrectomy, pars plana approach with endolaser panretinal photocoagulation	$3,000
67041	Vitrectomy, pars plana approach with removal of precellular membrane	$3,200
67042	Vitrectomy, pars plana approach with removal of internal limiting membrane of retina	$3,200
67113	Repair of complex retinal detachment with vitrectomy and membrane peeling, including, when performed, air, gas, or silicone oil tamponade, cryotherapy, endolaser photocoagulation, drainage of subretinal fluid, scleral buckling, and/or removal of lens	$3,684
Other	Clinic follow-up appointment	$95
Other	Optical coherence tomography	$65

Abbreviation: CPT, Current Procedural Terminology.

Table 2. Patient Demographics.

Demographic	Overall	Clinic Cohort	Operating Room Cohort
Patients (n)	53	16	38
Eyes (n)	82	26	56
Age (y)			
Mean ± SD	52.7 ± 13.7	55.0 ± 10.9	51.6 ± 14.8
Range	24, 81	38, 75	24, 81
Sex			
Male, n (%)	37 (45.1)	10 (38.5)	27 (48.2)
Female, n (%)	45 (54.9)	16 (61.5)	29 (51.8)
Mean follow-up (mo) ± SD	53.6 ± 9.7	57.2 ± 11.0	52.0 ± 8.55
Insulin dependence, n (%)	59 (72.0)	18 (69.2)	41 (73.2)
Mean preoperative HbA_{1c} (%)	8.4 ± 1.7	8.9 ± 1.8	8.1 ± 1.6
Preoperative logMAR BCVA			
Mean ± SD	0.31 ± 0.39	0.28 ± 0.23	0.33 ± 0.45
Range	0, 2.3	0, 1	0, 2.3
Postoperative logMAR BCVA			
Mean ± SD	0.44 ± 0.60	0.75 ± 0.81	0.30 ± 0.40
Range	0, 2.3	0, 2.3	0, 2.3

Abbreviations: BCVA, best-corrected visual acuity; HbA_{1c}, glycosylated hemoglobin.

more data and an increased follow-up time to April 1, 2024, eyes with the initial PRP treatment performed in the operating room had significantly fewer subsequent PRP treatments than those with initial treatment performed in the clinic (1.0 vs 2.1; $P < .05$) and significantly fewer surgical interventions requiring PPV during the follow-up (0.3 vs 0.7; $P < .05$). There was no significant difference between the cohorts in subsequent injections or focal laser treatment. Table 3 also shows a cost analysis of patient follow-up. There was no statistically significant difference between the cohorts in the cumulative cost per patient ($P = .79$). Furthermore, when cost was averaged over the patients' follow-up period, there was no significant difference in the calculated mean cost per patient-treatment year ($P = .75$).

Table 4 shows the preoperative and postoperative logMAR BCVA as well as the change in BCVA. An analysis of long-term follow-up found significantly better BCVA after treatment in the operating room cohort than in the clinic cohort ($P < .05$). The mean change in BCVA before and after treatment showed a similar trend, favoring the operating room cohort ($P < .001$).

Subsequent surgical interventions requiring PPV in the entire study population included TRD repair (n = 8) and epiretinal membrane removal (n = 5) (Table 5). Overall, a mean cost of $5,886.79 per patient-treatment year was accrued by patients with initial PRP performed in the operating room and $5,657.50 by patients with initial PRP performed in the clinic ($P = .75$) (Table 4 and Figure 1).

Conclusions

PRP remains a mainstay treatment for the advanced neovascular phase of DR and reduces the risk for PDR progression by 50%.[21] Its key benefit lies in permanent scarring of the peripheral ischemic retina with subsequent regression of aberrant proliferative vessels, leading to a longer duration of therapy and the need for less

Table 3. Comparison of Subsequent Interventions and Total Cost by Initial Treatment Location.

Parameter	Clinic Cohort (n = 26)	Operating Room Cohort (n = 56)	*P* Value[a]
Surgeries	0.7	0.3	< .05[b]
Additional PRP	2.1	1.0	< .05[b]
Injections	5.8	7.1	.53
Focal laser treatments	1.1	0.8	.41
Clinic visits	22.1	25.8	.21
OCT scans	18.3	22.3	.13
Average cumulative cost	$26,268.37	$25,402.21	.79

Abbreviations: OCT, optical coherence tomography; PRP, panretinal photocoagulation.
[a]Negative binomial regression for count of subsequent interventions (2-tailed unpaired samples *t* test for total cost).
[b]Statistically significant ($P \leq .05$).

Table 4. Comparison of Initial and Final LogMAR BCVA.

LogMAR BCVA	Clinic Cohort (n = 26)	Operating Room Cohort (n = 56)	*P* Value[a]
Preoperative	0.28 ± 0.23	0.33 ± 0.45	.54
Postoperative	0.75 ± 0.81	0.30 ± 0.40	<.05[b]
Change	−0.47 ± 0.79	0.03 ± 0.49	<.001**

Abbreviation: BCVA, best-corrected visual acuity.
[a]Two-tailed unpaired samples *t* test.
[b]Statistically significant ($P \leq .05$).
**Significance of the *p*-value.

follow-up than with anti-VEGF injections alone.[22] Consistent monitoring is critical for treatment, and outcomes are affected when patients are lost to follow-up.

One study reported a lost-to-follow-up rate of 25.4% across a 5-year period. Of note, components that influenced patients' decisions were younger age, lack of disease concern, treatment affordability, and lack of transportation/social support.[23] Similarly, a retrospective cohort study using the IRIS Registry found that approximately 1 in 9 patients were lost to follow-up for more than 12 months after their last intervention (PRP, anti-VEGF, or combination therapy) and had a significant decline in VA compared with patients who maintained consistent appointments. Unilateral disease, a baseline VA of 20/50 or worse, ethnicity with cultural beliefs, language barriers, trust in the healthcare system, and health literacy were all noted as factors contributing to patients being lost to follow-up.[24] These are significant challenges to patients and providers in the chronic management of PDR, and while in many cases they are unavoidable,[22] they further burden patients and healthcare systems with additional costs.

As shown in our previous work, initial therapy in the operating room results in long-term benefits, including the need for less subsequent PRP and surgical management.[11] The current study aimed to analyze the cost benefit of initial intervention in the operating room compared with in the clinic, factoring in the necessity for subsequent procedural therapy in the patient's follow-up course.

Table 5. Subsequent Interventions.

Intervention	Total (n = 82)	Clinic Cohort (n = 26)	Operating Room Cohort (n = 56)
Injections	545	150	395
PRP	112	54	58
Focal laser	70	28	42
Total surgeries (PPV)	37	17	20
TRD repair	8	6	2
Epiretinal membrane removal	5	1	4

Abbreviations: PPV, pars plana vitrectomy; PRP, panretinal photocoagulation; TRD, tractional retinal detachment.

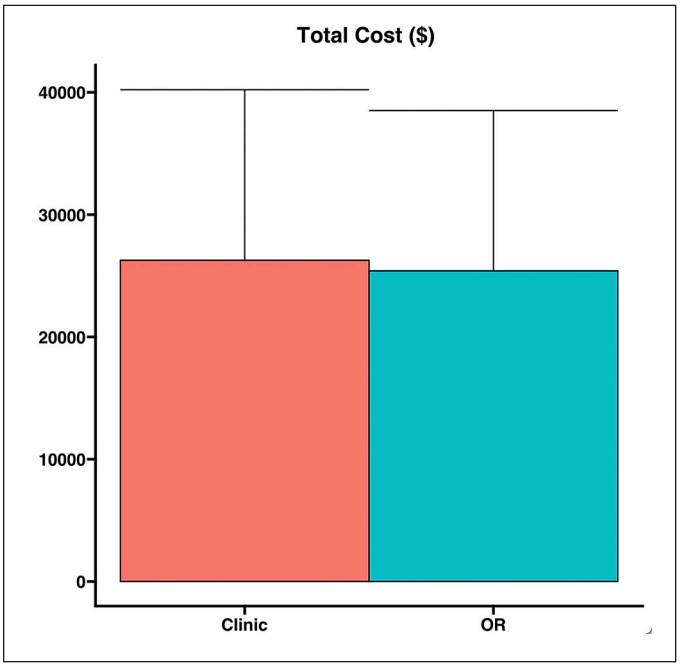

Figure 1. The mean total cost per patient between cohorts.
Abbreviation: OR, operating room.

Previous analyses in our patient population showed significantly fewer subsequent surgical procedures and PRP in the operating room cohort than in the clinic cohort over a mean follow-up of 44 months.[11] A similar trend was found in the continuation of our analysis with additional follow-up data (mean, 53 months). Improved pain control in the operating room with combined intravenous sedation (midazolam or propofol) and topical anesthesia (tetracaine) as opposed to topical anesthesia alone in the clinic may explain these results. Pain has been associated with a negative impact on PRP, reducing the total amount of laser therapy provided to patients and potentially affecting their compliance.[25] The preemptive anesthesia options in the operating room offer more complete analgesia with the possibility of affording better visualization and more complete therapy to the peripheral retina. We recognize that retrobulbar anesthesia in the clinic can provide better pain control than topical anesthesia but not without the risk for a potentially blinding retrobulbar hemorrhage.

These benefits come at the cost of additional expense, with treatment in the operating room requiring facility and anesthesia charges (averaged as $8,000 at our institution) that are absent in the clinic setting. However, when making long-term comparisons, this initial expense in the operating room matches the expenses observed in our clinic cohort with required additional interventions (Table 3, Table 5, and Figure 1). Furthermore, the final mean improvement in BCVA was significantly higher in the operating room cohort than in the clinic cohort with the addition of follow-up data to April 1, 2024 (mean, 53 months). We hypothesize that the lower VA outcomes in the clinic group may have been the result of inadequate control of PDR; however, worse baseline macular ischemia cannot be ruled out in the absence of baseline fluorescein angiography or optical coherence tomography angiography.

Our study's limitations include discrepancies in case numbers between the cohorts (more patients were included in the operating room group) and PRP being performed by multiple surgeons with varying levels of experience. Facility and anesthesia charges were based on cost data at our institution and may vary from those at other facilities. Cost data based on operating room time for PRP cases were not available for analysis.

Another limitation is the inclusion of patients with previous anti-VEGF treatment for DME before initial PRP. Previous anti-VEGF therapy can certainly alter the disease course in DR. However, we believe that the study sample is still valid because DME is often present in concert with PDR and many patients in the real world have had previous anti-VEGF therapy before initial PRP. In addition, there was no statistical difference between the groups in the number of anti-VEGF treatments before PRP ($P > .05$). Other potential limitations entail those associated with retrospective chart reviews, including sampling bias, missing or incomplete data, lack of preoperative fluorescein angiography for all patients, and a variable follow-up time.

In conclusion, PRP initially administered in the operating room was equal in cost to PRP performed in the clinic with the incorporation of subsequent therapeutic interventional cost over patient follow-up. Patients in the operating room cohort required fewer subsequent PRP sessions and surgical treatments and had a significantly higher final BCVA than the clinic cohort. These results show a consistent trend for more subsequent interventions required overall in the clinic cohort than in the operating room cohort, as discussed in our previous study (mean follow-up, 44.2 months vs 53.6 months).[7] As such, PRP in the operating room appears to be a reasonable consideration, both from a cost and therapeutic standpoint, for the initial treatment of PDR. Patients with a systemic health status amenable to anesthesia in the operating room are ideal candidates, with special considerations for those intolerant of treatment in the clinic because of discomfort or anxiety.

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Jonathan S. Fuerst, MD, conceived the initial project and data collection.

Ethical Approval

This research was conducted in accordance with the Declaration of Helsinki. The collection and evaluation of all protected patient health information were performed in a US Health Insurance Portability and Accountability Act–compliant manner.

Statement of Informed Consent

Informed consent was waived by the University of Alabama at Birmingham Institutional Review Board given the retrospective nature of this study.

Declaration of Conflicting Interests

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