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Ten surgical pearls adapted from ancient Chinese allusions in managing severe proliferative diabetic retinopathy

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典故赋能眼科手术:从传统策略中提炼严重增殖性糖尿病视网膜病变手术要领

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摘要

目的:总结 10 个源自中国典故传统策略在治疗增殖性糖尿病视网膜病变的手术要领,在真实世界中分析这些要领的应用情况。

方法:回顾性、非对比性、干预性的研究。从 10 个源自古代中国哲学的传统策略(釜底抽薪、知己知彼、擒贼擒王、围城打援、融会贯通、分而治之、见缝插针、隔山打牛、左右开弓、四两拨千斤)总结并提炼手术要领。选取于 2016-01/2024-02 在我院行经睫状体平坦部玻璃体切除术 346 例 443 眼。根据每例患者的具体情况,在手术中灵活组合并使用这些技术要领。根据是否存在牵拉性视网膜脱离,分析这些技术要领的应用频率、有效性和安全性。

结果:纳入的所有患者共进行了 473 次手术。结合中国典故传统策略,提炼出 10 个手术要领。应用这些要领的不同组合,所有玻璃体切除术都进展顺利,除 10 例 11 眼外,其余患者均成功剥除增殖膜。而这 11 眼,应用了第十项技术策略(最小量膜切除法),即只做必要的松解切口,故意保留大部分增殖膜。最终视力较术前改善或稳定(LogMAR 视力:术前 1.92±0.83 *vs* 术后 1.16±0.85,$P<0.01$)。术后主要并发症包括早期的前房炎症反应和晶状体的核硬化。玻璃体切除术后复发性玻璃体出血、视网膜脱离和前房积血或新生血管性青光眼的发生几率分别为 1.9%(9/473)、3.2%(15/473)、0.4%(2/473)和 0.4%(2/473)。其中黄斑区视网膜脱离占 1.9%(9/473),再行多次玻璃体切除术。最终,98.9%患眼实现了黄斑区视网膜复位。未复位的 5 眼均存在严重的增殖膜和继发性硅油下视网膜脱离,其中 3 眼进行了巩膜外加压术。

结论:这 10 个传统策略提炼的技术要领在处理严重增殖性糖尿病视网膜病变时,绝大部分有效且安全。深入理解了每个典故传统策略的含义,记忆和应用这些要领会相对容易。可根据患者的具体情况来灵活应用不同的组合。

关键词:手术要领;中国典故;中国成语;增殖性糖尿病视网膜病变;经睫状体平坦部玻璃体切除术

Abstract

• AIM: To summarize 10 surgical pearls for managing proliferative diabetic retinopathy (PDR) adapted from the ancient Chinese allusions and analyze the application of these pearls in a real-world fashion.

• METHODS: Retrospective, noncomparative, interventional study. Ten surgical pearls were summarized and adapted from the ancient Chinese philosophy. Totally 346 cases (443 eyes) that underwent pars plana vitrectomy (PPV) at our hospial from January 2016 to February 2024 were selected. Flexible combinations of these pearls were applied according to the specific condition of each patient during surgeries. The efficacy and safety were analyzed, as well as the application frequencies according to the existence of tractional retinal detachment or not.

• RESULTS: A total of 473 times of surgeries were performed on all the patients. According to ancient Chinese allusions, ten surgical pearls were summarized from these surgeries. All PPVs went smoothly with the

application of different combinations. Finally, almost all proliferative membranes were successfully peeled except for 10 patients (11 eyes), who went through strategy No. 10 (minimal membranectomy) that, only necessary relaxation incisions were made with most of the proliferative membranes left on purpose. The final visual acuities were mostly improved or stable (1.92±0.83 LogMAR preoperatively *vs* 1.16±0.85 LogMAR postoperatively, $P<0.01$). Postoperative complications mainly included early inflammatory responses in the anterior chamber and nuclear sclerosis. Recurrent vitreous hemorrhage, retinal detachment, and hyphema or neovascular glaucoma occurred in 1.9% (9/473), 3.2% (15/473), 0.4% (2/473) and 0.4% (2/473) times of PPVs, respectively. After 12/473 (2.5%) times of PPVs, retinal detachment at the macular area still existed, and multiple times of subsequent PPVs were conducted. Final retinal attachment at the macular area was realized in 98.9% eyes. Those 5 unattached eyes were with heavily reproliferated membranes and subsequent tractional retinal detachment recurrence under the oil, and three of them were scleral buckled additionally.

• CONCLUSION: These 10 surgical strategies and technique pearls were mostly effective and safe in the management of severe PDR patients. They were relatively easy to be memorized and applicated once the meaning of each Chinese idiom was understood. One can use different combinations flexibly according to a patient's specific condition.

• KEYWORDS: surgical pearls; ancient Chinese allusions; Chinese idioms; proliferative diabetic retinopathy; pars plana vitrectomy

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INTRODUCTION

The global epidemic of diabetes is a significant challenge for public health and ophthalmology in particular, as diabetic retinopathy, one of the leading causes of preventable vision loss is increasing. The most common ultimate and visually impairing complications of diabetic retinopathy is proliferative diabetic retinopathy (PDR), which might further advance into a subsequent severe form - tractional retinal detachment (TRD) or cause many non-TRD complications. Pars plana vitrectomy (PPV) has been used extensively to treat this stage of diabetic retinopathy. During the surgery, removing of the proliferative membranes with the least or even no iatrogenic retinal holes is the most difficult task. Various instruments, such as membrane hooks, vertical and/or horizontal scissors, diathermies, chandeliers, high/ultra-high cutting rate small gauge vitrectors, *etc.*, have been developed to try to achieve this purpose, meanwhile, many surgical strategies and techniques have also been adapted, such as segmentation[1], perfluorodissection[2], viscodissection[3], hybrid-gauge technique[4-5], bimanual technique[6], lift-and-shave technique[7], *etc.* Even so, a failure of surgery happens sometimes.

The ancient Chinese illusions are a treasure of wisdom. Several world-famous military masterpieces, such as, "*The Art of War by Sun Tzu*", "*Thirty-Six Stratagems*", *etc.*, as well as many Chinese idioms, all originated from them. This kind of ancient Chinese philosophy has a very far-reaching impact on Eastern and Western military thinking, business tactics, legal strategies, manners and beyond, that even the common people nowadays know them by name.

In a way, PDR surgery is like a war, during which, many of those tricks are also applicable. This study tried to summarize ten surgical pearls originated from such wisdom, which were applied in the process of our surgical PDR management. To our knowledge, there was little or no previous literature that has analyzed different strategies and techniques in detail, as well as their applications in different scenarios in PDR related PPV surgery.

SUBJECTS AND METHODS

Ethical Approval Medical records and surgical videos of 346 consecutive patients (443 eyes) with a diagnosis of PDR from January 2016 to February 2024 who underwent PPVs in the ophthalmology department of Peking Union Medical College Hospital were reviewed retrospectively. This study was approved by the Ethics Committee of Peking Union Medical College Hospital (No.JS-3253). Written informed consents were obtained from each patient before surgery. And this study adhered to the tenets of the Helsinki Declaration.

Subjects This was a retrospective non-comparative interventional study. Preoperative records included the age at operation, gender, diabetic types, systemic diseases and preoperative intravitreal injections of anti-vascular endothelial growth factor (VEGF) agents. Intraoperative findings, anatomical and functional outcomes, and postoperative complications were also collected. All patients were followed up for 6 mo at least.

Preoperative and postoperative ocular examinations included best corrected visual acuity (BCVA), intraocular pressure, slit-lamp examination, ocular fundus examination, scanning laser ophthalmoscope, optic coherence tomography and ocular B-scan ultrasonography. BCVA was checked by the visual chart for decimal measurement and was changed into logarithm of minimum angle of resolution (LogMAR) form for the sake of statistics. All patients had been examined in detail with dilated pupils. Exclusion criteria included eyes with no light perception before surgery, patients with severe systemic diseases, abnormal coagulant functions, incomplete records of clinical and accessory examinations, eyes with previous intraocular surgery history, and eyes complicated with ocular trauma, ocular tumors, uveitis, or other severe ocular diseases.

All PPVs were performed by 3 surgeons, Chen Z (29 times), Wu C (28 times) and Dai RP (the rest), using a standard

three-port 23G/25G vitrectomy system (Stellaris PC; Bausch & Lomb, Rochester, NY, USA) equipped with a wide-angle noncontact viewing system (Resight; Carl Zeiss Meditech AG, Jena, Germany). Flexible combinations of several surgical pearls were used. Subconjunctival corticosteroids and postoperative antibiotic ointments were administered at the end of the surgical procedures.

Here we summarized the ten surgical pearls as follows and explained how they were conducted:

1) 釜底抽薪 (fǔ dǐ chōu xīn, take away the firewood under the cookingpot). This strategy meant to give intra-vitreous injections of anti-VEGF agents 3-7 d preoperatively.

2) 知己知彼 (zhī jǐ zhī bǐ, know the enemy and know yourself). This strategy meant to do scanning laser ophthalmoscope, optic coherence tomography and/or B-scan ultrasonography examinations preoperatively. It also meant to enlarge the view of the posterior pole by changing the widefield lens with the macular lens of the non-contacting widefield system to discern the details of the posterior pole more clearly.

3) 擒贼擒王 (qín zéi qín wáng, to defeat the enemy by capturing their chief). This strategy meant before doing vitrectomy extensively, trying to make a posterior vitreous detachment at the point of optic disc first. More commonly in the situation of severe TRD, not the entire posterior hyaloid but instead, only the heavily proliferated membranes around the disc could be lifted by grasping the firm rim of the membrane-Weiss ring complex without causing iatrogenic holes here and there.

4) 围城打援 (wéi chéng dǎ yuán, besiege a city to annihilate the enemy reinforce). This strategy meant to cut off all the connected surrounding vitreous of the intensively proliferated membranes to release all the possible traction forces, before focusing on the isolated membrane itself (Figure 1).

5) 融会贯通 (róng huì guàn tōng, substitute one instrument with another based on the essential purpose of the maneuver). This technique meant to pick up the free ends of the proliferative membrane with the forceps in one hand and make the light probe function as a scissor with the other hand.

6) 分而治之 (fēn ér zhì zhī, divide and conquer). This technique meant to cut a large dense membrane into several small pieces and then manage each of them one-by-one.

7) 见缝插针 (jiàn fèng chā zhēn, stick in a pin wherever there's room). This technique meant to insert the vitrectomy probe into wherever a space between the proliferative membrane and the retina was found.

8) 隔山打牛 (gé shān dǎ niú, fighting the cattle across the mountain). This technique meant to place the vitrectomy probe above the proliferative membrane, close enough to but not contacting it directly, fold-back the free ends by aspiration, and then do the consumption (Figure 2).

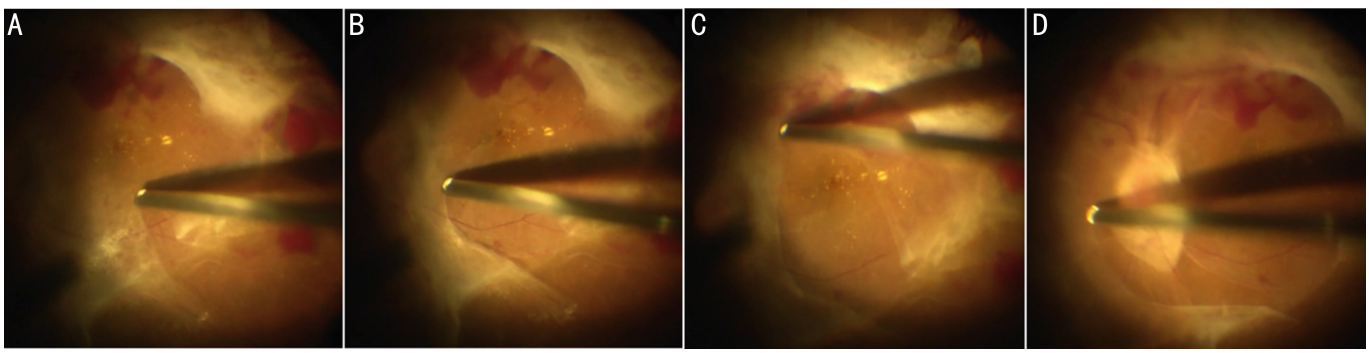

Figure 1 Example of "围城打援" (wéi chéng dǎ yuán, besiege a city to annihilate the enemy reinforce). A: Find a breakthrough point, insert the vitrectomy probe into the narrow space between the posterior hyaloid and the retina, cut through and advance; B, C, D: Enlarge the area around the target-the pre-optic proliferative membrane and isolate it from its surroundings before starting to manage the membrane itself.

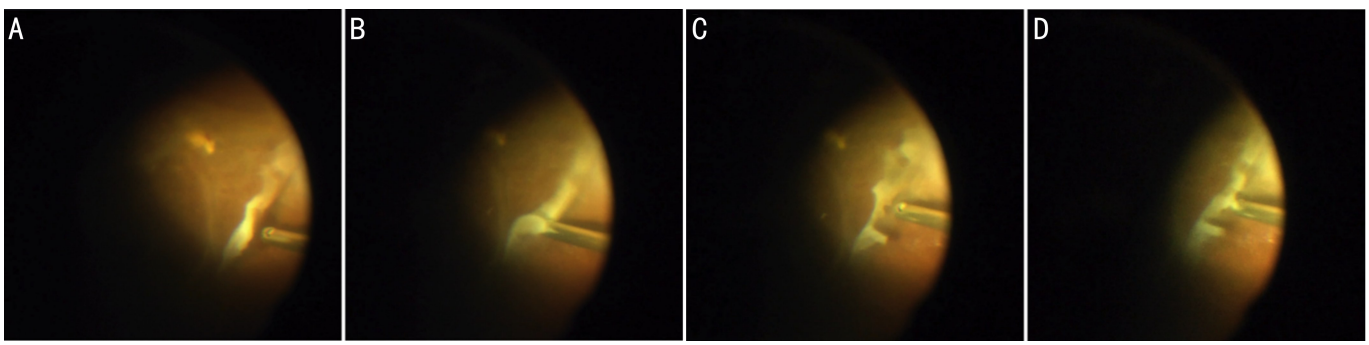

Figure 2 Example of "隔山打牛" (gé shān dǎ niú, fighting the cattle across the mountain). A: Place the vitrectomy probe over the proliferative membrane, but don't contact it directly, then fold back the free ends of the membrane by the aspiration force of the probe; B: Do the consumption; C: Moving the probe alongside the border of the membrane, and repeat maneuver A; D: Repeat maneuver B. In this way, the adhesion between the membrane and the retina can be released without direct contact.

9）左右开弓（zuǒ yòu kāi gōng, draw the bow both on the left and right）. This technique meant to apply the instrument in one hand and complement it with another instrument in the other hand when doing delamination maneuvers. Two hands coordinate closely to each other to accomplish the peeling task. A third-party illumination system（usually one or two chandelier lights）is required.

10）四两拨千斤（sì liǎng bō qiān jīn, four ounces can move a thousand pounds）. This strategy was also called minimal membranectomy. It meant only necessary relaxation incisions were done during the dissection stage. Not all the fibrotic membranes were mandatorily removed. Retinal detachment was allowed if the detached areas were stable and unlikely to advance towards the macula. Endolaser photocoagulations were done as much as possible during the surgery, with necessary indentations. During the postoperative follow-up stage, additional photocoagulations were made where the subretinal fluid was further absorbed.（Figure 3）.

These ten surgical pearls were used in flexible combinations according to the specific condition of each patient.

Statistical Analysis The age at operation and the pre-/post-operative BCVAs were demonstrated as mean±standard deviation. The other demographic data and clinical results were demonstrated in numbers and calculated as proportions. The significance of the BCVA changes were analyzed using paired t-test（preoperative versus postoperative of each patient's each eye in each time of PPV）. Cross-tabulation analysis was done to the application frequencies of these 10 surgical pearls according to the existence of TRD or not. The efficacy and safety of them were demonstrated through these numbers.

RESULTS

The demographic data and clinical characteristics were listed in Table 1. Ten surgical pearls adapted from the ancient Chinese philosophy were summarized. Each was given a Chinese idiom name for the convenience of understanding and memorizing. All surgeries went smoothly. The anatomic states of most patients improved after surgery. Most of the final BCVA increased or remained stable compared to the preoperative BCVA, excepted for a few severely complicated cases. Postoperative complications mainly included early inflammatory responses in the anterior chamber, especially when phacovitrectomy was performed, and nuclear sclerosis if the lens was not extracted at the same time. Ordinary postoperative anti-inflammatory eyedrops or cataract surgeries were administered to solve these problems. A few postoperative complications needed surgical intervention again. Final retinal attachment at the macular area was achieved in the majority

Table 1 Demographic data and clinical characteristics before surgery

Characteristics	Results
Patients(eyes)	346（443）
PPVs（n）	473
Gender（n, %）	
Male	177/346（51.2%）
Female	169/346（48.8%）
Age at operation（$\bar{x}\pm s$, years）	53.01±10.92
Diabetes mellitus type（n, %）	
Type 1	20/346（5.8%）
Type 2	324/346（93.6%）
LADA	2/346（0.6%）
Systemic disease（n, %）	
Hypertension	191/346（55.2%）
Kidney disorders	93/346（26.9%）
Cardiovascular diseases	46/346（13.3%）
Side（n, %）	
Right	120/346（34.7%）
Left	129/346（37.3%）
Bilateral	97/346（28.0%）
Type of pathogenesis（n, %）	
TRD	271/473（57.3%）
Non-TRD	202/473（42.7%）
ERM	11/202（5.4%）
Simple VMT	1/202（0.5%）
MH	10/202（0.5%）
VH and the subsequent non-TRD preretinal proliferation	177/202（87.6%）

PPV: Pars plana vitrectomy; LADA: Latent autoimmune diabetes in adults; TRD: Tractional retinal detachment; ERM: Epiretinal membrane; VMT: Vitreous-macular traction; MH: Macular hole; VH: Vitreous hemorrhage.

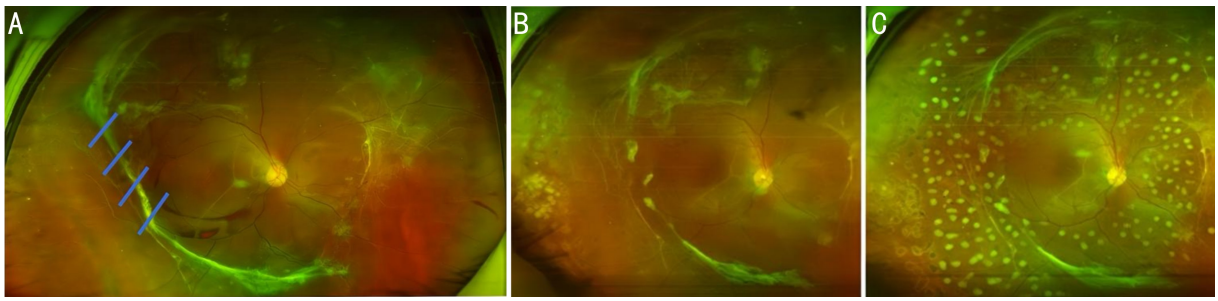

Figure 3 Example of "四两拨千斤" (sì liǎng bō qiān jīn, four ounces can move a thousand pounds). A: Preoperatively, the patient had a circular non-active proliferative fibrotic membrane which resulted in tractional retinal detachment. The preoperative best corrected visual acuity was 20/200. During surgery, only four relaxation incisions were made (indicated as blue lines) to effectively release the tractional force; B: One week post-operatively, several separated segments of the membrane could be seen between the incision sites; C: One month after the surgery, photocoagulations were added nearer to the macula because the subretinal fluid was further absorbed. The best corrected visual acuity became 20/133.

Table 2 Surgical results

Characteristics	Result	*P*
PPVs (*n*)	473	
Number of PPVs per eye (*n*, %)		
Once	451/473 (95.3%)	
Twice	15/473 (3.2%)	
Thrice	6/473 (1.3%)	
Quartic	0	
Quintic	1/473 (0.2%)	
Pre-op IVI of anti-VEGFs (*n*, %)	370/473 (78.2%)	
BCVA ($\bar{x}\pm s$, LogMAR)		
Pre-op	1.92±0.83	<0.01
Post-op	1.16±0.85	
Vitreous tamponade (*n*, %)		
Silicon oil	171/473 (37.0%)	
C_3F_8	43/473 (9.3%)	
BSS	248/473 (53.7%)	
Eyes achieved final retinal attachment at the macula (*n*, %)	443/438 (98.9%)	
Eyes with additional scleral bucking surgery (*n*, %)	3/438 (0.7%)	
Post-op complications that needed reoperation (*n*, %)		
Recurrent VH	9/473 (1.9%)	
Recurrent RD	15/473 (3.2%)	
Hyphema	2/473 (0.4%)	
NVG	2/473 (0.4%)	

Simple silicone oil extraction surgery was not included when number of surgeries per eye was calculated. LogMAR: Logarithm of minimum angle of resolution; PPV: Pars plana vitrectomy; IVI: Intravitreal injection; VEGF: Vascular endothelial growth factor; BCVA: Best corrected visual acuity; Pre-op: Preoperative; Post-op: Postoperative; C_3F_8: Perfluoropropane; BSS: Balanced salt solution; RD: Retinal detachment; VH: Vitreous hemorrhage; NVG: Neovascular glaucoma.

eyes. Those unattached 5 eyes were with heavy re-proliferation and subsequent TRD recurrence under the oil, and three of them were scleral buckled additionally. The surgical results were demonstrated in Table 2. A cross-tabulation analysis of the usage frequencies of these ten pearls according to the status of TRD or non-TRD were demonstrated in Figure 4.

DISCUSSION

There are several forms of complications of severe PDR, such as vitreous hemorrhage, epiretinal membrane, vitreomacular traction, macular hole, TRD and neovascular glaucoma, *etc*. They are all indications of PPV surgery. Among them, vitreous hemorrhage and TRD results from angiogenesis of the existing retinal vasculature growing across the potential space between the internal limiting membrane of the retina and the posterior surface of the vitreous cortex. In this process, the vitreoretinal interface was used as a scaffold, thereby creating firm adhesions between these two. Gradually, the fibrous tissue contracts, resulting in anteroposterior and tangential tractions on the retina. Excessive traction frequently causes the

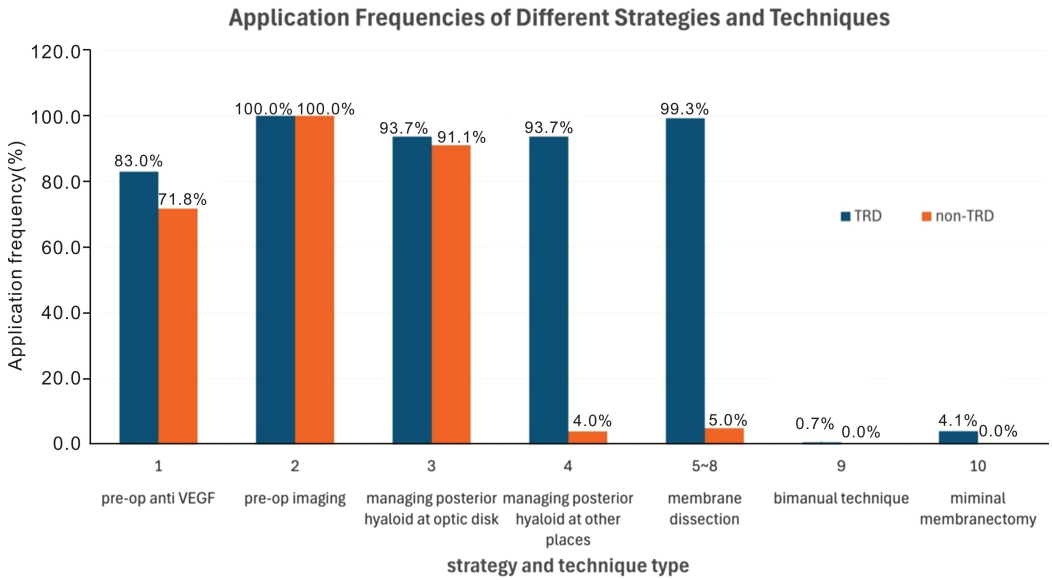

Figure 4 Application frequencies of different pearls. The blue bar represents cases of proliferative diabetic retinopathy with tractional retinal detachment, while the orange bar represents non-tractional retinal detachment cases, including epiretinal membrane, simple vitreous-macular traction, macular hole, neovascular glaucoma and de novo/recurrent vitreous hemorrhage or its subsequent minimal preretinal proliferation without causing tractional retinal detachment. The usage frequencies were demonstrated besides each bar. Strategy No.1 referred to "釜底抽薪"(fǔ dǐ chōu xīn, take away the firewood under the cookingpot), which meant pre-operative intravitreal injection of anti-vascular endothelial growth factor drugs; strategy No.2 referred to "知己知彼"(zhī jǐ zhī bǐ, know the enemy and know yourself), which meant pre-operative imaging; strategy No.3 referred to "擒贼擒王"(qín zéi qín wáng, to defeat the enemy by capturing their chief), which meant managing the posterior hyaloid at the optic disk first; strategy No.4 referred to "围城打援"(wéi chéng dǎ yuán, besiege a city to annihilate the enemy reinforce), which meant managing the posterior hyaloid at other sites of the retina before starting managing the membrane itself; techniques No.5-8 referred to "融会贯通"(róng huì guàn tōng, substitute one instrument with another based on the essential purpose of the maneuver), "分而治之"(fēn ér zhì zhī, divide and conquer), "见缝插针"(jiàn fèng chā zhēn, stick in a pin wherever there's room) and "隔山打牛"(gé shān dǎ niú, fighting the cattle across the mountain), respectively, representing different kinds of membrane dissection methods and were grouped as one; technique No.9 referred to "左右开弓"(zuǒ yòu kāi gōng, draw the bow both on the left and right), and meant the "real" bimanual technique; strategy No.10 referred to "四两拨千斤"(sì liǎng bō qiān jīn, four ounces can move a thousand pounds) and meant minimal membranectomy.

fragile new vessels to bleed into the vitreous and/or pre-retinal space and causes the retina to deform and detach. PDR related epiretinal membrane, vitreomacular traction and macular hole results from proliferation or excessive traction of the posterior hyaloid surface to the macula. Neovascular glaucoma results from severe ischemia of the retina and the subsequent signals facilitating neovascularization cascade reactions. To solve all these problems, a successful separation of the adhesions between the posterior hyaloid surface and the retina must be created. During this process, the membrane delamination maneuvers often accompany iatrogenic holes formation and inadequate relaxation of the tractional forces and the subsequent possible failure of the surgery.

Our ten surgical pearls used in flexible combinations exactly provided the appropriate methods to accomplish that, especially when the toughest work-managing PDR caused TRD-was attempted. These pearls were verified of their efficacy and safety as the results part showed.

In the following, we would like to explain how these surgical pearls were derived from the ancient Chinese philosophy, explain the results in this present study, and to compare them with the current literatures.

1) 釜底抽薪 (fǔ dǐ chōu xīn, take away the firewood under the cookingpot). This idiom means taking a drastic measure to deal with a situation, and the eliminated factor usually plays an important role in the event. As known to all, the VEGFs play an important role in the pathogenesis and progression of PDR. Applying intravenously anti-VEGF agents 3-7 d preoperatively could help reduce bleeding during the surgery and cause a short duration of the regression of neovascularization secondary to PDR and thus facilitate surgical dissection of the pre-retinal fibrosis[8]. Many previous literatures proved the effectiveness of pre-operative intravitreal injections of anti-VEGFs in the management of PDR patients[9-11]. According to Figure 4, in our 271 times of PPVs due to TRD, 225 (83.0%) received pre-operative anti-VEGF treatment, among which, only 5.3% (12/225) still had a post-operative macular retinal detachment. In the meta-analysis published in 2023 by Dervenis *et al*[9], this number was 9.0% (17/189). This may be due to other pearls also applied besides from this strategy.

2) 知己知彼 (zhī jǐ zhī bǐ, know the enemy and know yourself). This idiom means that one should know both himself and his counterpart to win each battle. In PDR

management, doing scanning laser ophthalmoscope, optic coherence tomography and/or B-scan ultrasonography examinations during the preoperative laying plan stage can help understanding better the relationships between the preretinal proliferative membranes and the retina[12]. In our case, pre-operative imaging modalities also were applied to each patient each time, no matter the status of TRD or non-TRD, the application frequency was 100.0%. More recently, some surgeons use intraoperative optic coherence tomography to comprehend better the anatomy in a real-time manner[13]. The most recent new technique was intraoperative three-dimensional fluorescein angiography-guided PPV, which also serves to this purpose[14]. Besides, during PPV process, enlarging the view of the posterior pole by changing the widefield lens with the macular lens of the system to discern the details more clearly also helps "knowing the enemy" better.

3) 擒贼擒王 (qín zéi qín wáng, to defeat the enemy by capturing their chief). When used in ancient Chinese military, this idiom means capturing the ringleader first in order to capture all the followers. Many things have this kind of "key point", seize it and you will get a doubled result with half the effort. In PDR management, some membranes are most adhesive at the site of optic disc. By grasping the pre-optic membrane, the entire rest of the membrane is much easier to be pulled away in an "inside-out manner" (from the posterior pole to the periphery). This resembles the technique of total *en bloc* excision[15-16]. More commonly, not the entire posterior hyaloid but only the heavily proliferative membrane around the disc can be lifted without causing iatrogenic holes compared to other sites. In the present study, this strategy was used with almost the equal frequencies in non-TRD and TRD patients (91.1% *vs* 93.7%) as demonstrated in Figure 4. It is not hard to understand that induction of a posterior hyaloid detachment is the basic step of a successful PPV surgery, no matter in non-TRD or TRD cases. The difference only lied in that whether it was a simple and easy separation that could be achieved just by aspiration force in non-TRD cases or forceps were needed in TRD cases.

4) 围城打援 (wéi chéng dǎ yuán, besiege a city to annihilate the enemy reinforce). This is originally an ancient Chinese military term, which means encircling the target city, and then destroying the reinforcement. In PDR management, you had better to cut off all the connected surrounding vitreous to release all the possible tractional forces from different directions, and then focus on the isolated densely adhesive membrane itself. Otherwise, iatrogenic holes would possibly form unexpectantly at this or other sites. In our present study, 93.7% (254/271) times of surgeries managing TRD used this strategy, while only 4.0% (8/202) in non-TRD cases. This huge difference was not hard to be understood, that, membrane proliferation and adhesion were much more severe in TRD scenarios, managing the hyaloid before the membrane itself could help reducing the iatrogenic holes formation during the membrane dissection process. While in non-TRD scenarios, the vitreous often could be pulled away by applying strategy No.3, and this strategy is no longer necessary.

5) 融会贯通 (róng huì guàn tōng, substitute one instrument with another based on the essential purpose of the maneuver). This idiom in ancient Chinese philosophy means achieving mastery through a comprehensive understanding. In PDR management, we should understand thoroughly the essence of the "real" bimanual manipulation. When using vitrectomy systems that has a light probe with a beveled tip, one can use forceps to pick up the free ends of proliferative membrane with one hand and make the light probe function as a scissor with the other hand, to release the sticking points between the membrane and the retina. Thus, a physical scissor and a chandelier light used in the "real" bimanual technique are no longer mandatory.

6) 分而治之 (fēn ér zhì zhī, divide and conquer). In ancient Chinese philosophy, this idiom means to divide a state, nation or religion by hook or by crook, and then rule them separately. It is easy to be understood: no matter a state or an army, it may be difficult to be defeated as a whole but is possible to be conquered as several separated parts. In PDR management, it refers to segmentation technique[1]. This is a resemble rationale of how divide-and-conquer technique is used in cataract surgeries[17]. By applying this technique, one could reduce the tractional force to other places of the retina to the gentlest level and avoid tractional hole formation as much as possible when dealing with one piece of the densely adhesive membrane.

7) 见缝插针 (jiàn fèng chā zhēn, stick in a pin wherever there's room). This idiom means to make use of every single space. Its extending meaning is to make use of every bit of time or avail oneself of every opportunity. In PDR management, it is used literarily, which means inserting the vitrectomy probe into wherever a space between the proliferative membrane and the retina was found. Such spaces are usually the breakthrough points of membrane delamination.

8) 隔山打牛 (gé shān dǎ niú, fighting the cattle across the mountain). This idiom is a term in traditional Chinese martial art. It means not to contact the target directly, but to use some kind of qigong to beat the enemy instead. In PDR management, it refers to the "fold-back delamination technique"[16]. By applying this technique, do not contact the membrane directly with the vitrectomy probe, but to fold back the free rim of the membrane by aspiration force, and then do the consumption. This technique has the advantage of safety (impossible to bite the retina tissue) but has a learning curve. These above No.5-8 techniques were grouped as one entity in Figure 4 as membrane dissection technique, and they were used extensively in our TRD cases (99.3%, 269/271) compared to seldomly in our non-TRD cases (5.0%, 10/202). To our knowledge, there were no current literatures revealing this matter in detail in PDR PPV surgeries.

9) 左右开弓 (zuǒ yòu kāi gōng, draw the bow both on the left and right). This idiom is used literarily in PDR management, and it refers to the "real" bimanual

technique[6]. However, in our cases, it was used seldomly (0.7% in TRD scenarios), because with the application of technique No.5, this technique was no longer necessary in most cases, unless the adhesion of the proliferative membrane and the subsequent TRD was so broad and severe that, a beveled-tip light probe could not separate the adhesions effectively.

10) 四两拨千斤 (sì liǎng bō qiān jīn, four ounces can move a thousand pounds). This idiom is just like the famous Western proverb said by Archimedes, "Give me a lever long enough and a fulcrum on which to place it, and I shall move the globe." It means to accomplish a great task with little effort by clever maneuvers. In PDR management, some patients' situations are so severe that, if thorough membrane delamination is performed, it usually results in a silicon-oil dependent eye and consequences follows. Instead, one can use minimal membranectomy to bring about less trauma yet the same effect of relief of vitreoretinal traction. Eleven eyes of 10 patients in our study went through this strategy. This was explained in detail in our another work and is under peer review right now.

With application of flexible combinations of the above ten pearls, we conducted all surgeries smoothly. And the functional results (demonstrated as BCVA changes) and structural results (demonstrated by post-operative imaging, macular reattachment rate, and complication rates) were both good.

To our knowledge, there's no previous work had done application frequency analysis of different pearls with regards to the status of PDR related TRD or non-TRD yet.

In summary, just as water retains no constant shape, so in surgery there are no constant conditions. Only he who can modify his tactics in relation to his opponent, can succeed finally. In PDR related PPV surgeries, this means to apply different combinations of pearls flexibly according to the specific conditions of the fundi so that one can conduct the surgeries smoothly. In this study, we summarized ten surgical pearls that adapted from the ancient Chinese philosophy, and creatively gave each of them a Chinese idiom name for the convenience of understanding and memorizing. They were used abundantly in different scenarios, and their efficacy and safety were verified.

However, the weak points lay in that, in PDR related PPV surgeries, some strategies or techniques besides from these ten were omitted due to the lack of their popularity or our familiarity. And this study was retrospective. Further prospective work focusing on more strategies or techniques might make up these defects.

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