Clinical outcomes and preoperative predictive factors of success in single pneumatic retinopexy for primary rhegmatogenous retinal detachment at a tertiary care center.

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Purpose: To evaluate the success rate of pneumatic retinopexy (PR) for treatment of primary rhegmatogenous retinal detachment (RRD) and to explore preoperative factors associated with the success rate of PR.

Methods: We conducted a retrospective study, having reviewed medical records of all patients diagnosed with primary RRD that underwent a single PR in Thammasat university hospital, Thailand, during 2016 to 2018. Preoperative ocular characteristics, postoperative anatomical and visual outcomes were collected.

Results: 68 eyes of 68 patients were enrolled. Success rate of a single PR was 42.6%. The significant predictors were location of lowest retinal breaks \( (P < 0.001) \) and extension of retinal detachment \( (P < 0.002) \). In multivariate logistic regression analysis for the group with successful outcome, the patients whose lowest retinal breaks were located within the superior 2 clock hours were found to be 13.55 times more likely to respond successfully to PR \((\text{OR}=13.55, 95\%\text{CI }3.82-48.01, P<0.001)\). The success rate of PR was 0.722 times when the extension of retinal detachment increased for 1 clock hour \((\text{OR}=0.722, 95\%\text{CI }0.535-0.974, P=0.033)\). Out of the 29 patients from the success group, 27 (93%) patients had improvement of BCVA. Postoperative complications included new or missed break (12%), subconjunctival gas (10%), raised IOP (4%), vitreous haemorrhage (3%) and subretinal gas (1%).

Conclusion: The success rate of a single PR in primary RRD was 42.6%. The location of lowest retinal breaks and extension of retinal detachment were significant preoperative predictors of success in single PR for RRD. Final BCVA was improved in most patients with successful PR.

Keywords: pneumatic retinopexy; rhegmatogenous retinal detachment; success; factors; complication

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Introduction

Rhegmatogenous retinal detachment (RRD) is a condition in which the neurosensory retina is separated from the retinal pigment epithelium. RRD is the sight threatening ocular disease as well as one of considerable causes of blindness in Thailand. Nowadays, there are several treatments of this condition, which have different strengths and weaknesses, for instance, scleral buckling, pars plana vitrectomy (PPV) and pneumatic retinopexy (PR).

PR is a minimally invasive, non-incisional procedure which comprises of 2 steps; The first step is injecting an expandable gas such as perfluoropropane \((C_3F_8)\) or sulfur hexafluoride \((SF_6)\) into vitreous cavity, then the second step is applying laser retinopexy or transconjunctival cryopexy to induce a chorioretinal adhesion around all retinal breaks. The benefits of this procedure, is that it is cost-effective, faster

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postoperative recovery and safe. It is effective for RRD with breaks at the superior clock-hours, which is the majority of RRD cases, without the need for a vitrectomy system. However, the reasons for underutilization are that this procedure does not relieve vitreoretinal traction, and also need for skillful ophthalmologist to take more preoperative time in order to find all retinal breaks. The most common complication of PR is redetachment secondary to missed break or new break. Moreover, The other complications are cataract formation, raised IOP, suprachoroidal gas, subconjunctival gas, subretinal gas, macular hole, cystoid macular edema. Many studies reported the factors affecting the success rate of PR including pseudophakic/aphakic status, extension of retinal detachment, location of retinal break and vitreous hemorrhage. Currently, recent reports suggest a variety of success rates and predictive factors. The overall objective of this study was to evaluate the success rate of PR, in terms of anatomic and functional outcome, for treatment of primary RRD. The other purpose of this study was to define the preoperative factors which predict the success rate of PR. The complications related to this procedure were also analyzed.

Methods
Subjects
This retrospective analysis was approved by the Institutional Review Board of Thammasat University hospital in 2018. We reviewed the medical records of all patients who were diagnosed with primary RRD and underwent PR in Thammasat University Hospital, Thailand, during 2016 to 2018. The inclusion criteria were retinal breaks that are confined to the superior 8 clock-hours, a single retinal break or multiple breaks within 1–2 clock-hours, the absence of proliferative vitreoretinopathy (PVR) grade C or D, the cooperative patients who can maintain proper positioning and clear media. We excluded the patients who were diagnosed with glaucoma, history of previous retinal surgery, other ocular disease affecting visual function and the patients who lost follow-up before 6 months.

Surgical techniques
A similar PR technique was performed in all patients. The ophthalmologists examined and identified all the retinal breaks. The risk, benefit and complications were explained to the patients. The patients signed an informed consent. The PR was performed at operating room. Topical anesthesia (0.5%Tetracaine hydrochloride) was applied. Anterior chamber paracentesis was performed. Then, 0.3 ml of C3F8 was injected into vitreous cavity, in other words, 3.5 millimeters peripherally from limbus for pseudophakic/aphakic patients and 4 millimeters distant from limbus for phakic patients. We used C3F8 instead of SF6, because C3F8 has a longer duration of action (30-45 days) and more expansile than SF6. Zero-point-three ml of C3F8 was used, because the gas bubble will slowly expand over days to a volume of 1.2 ml allowing for slow equilibration of intraocular pressure. Afterwards, patients were assigned to position individually in order to apply gas on the detached retina. Lastly, laser retinopexy was performed on postoperative day 1 or day 2 if the retina around the retinal holes were considered sufficiently flat to perform an effective laser retinopexy.

Data collection
The data collected included age, gender, duration of symptoms, history of trauma, side of RRD. Clinical examination data were collected containing best corrected visual acuity (BCVA) by Snellen chart, intraocular pressure (IOP), lens status, number of retinal breaks, location of lowest retinal breaks, RRD extension, PVR grade, macular status. Postoperative data were collected including BCVA, IOP, area of retinal detachment and complications (such as raised IOP, new or missed break subconjunctival gas, subretinal gas, macular hole, cystoid macular edema, suprachoroidal gas and cataract progression) at 1 day, 7 days, 1 month, 3 months and 6 months. The definitions used in this study are as follows: 1) a single PR success was defined as the accomplishment of anatomically attached retina after a single PR. 2) VA improvement was defined as a gain of one or more lines or final VA equal 20/30 or better.

Statistical analysis
The data was collected in a standardized form, and stored in an electronic datasheet (Microsoft Excel). Descriptive statistics were shown as mean +/- standard deviation for continuous variables. Mann-Whitney U test was chosen for comparison. Furthermore, we
used frequency and percentage for categorical variables. Chi-square or Fisher’s exact test was chosen for comparison. We performed multiple logistic regression analysis to determine the association between factors and success of PR. The significance level was set at P< 0.05. Statistical analysis was conducted using SPSS software version 22.

**Result**

Our study sample comprised of 68 eyes of 68 patients with primary RRD that met the inclusion criteria. Patient demographic features were summarized in Table 1. The mean age at presentation was 58.18 ± 8.79 years. The proportion of gender was not different (male 48.5%, female 51.5%). The retinal detachment was located in the right eye 51.7% of cases. The mean duration of symptoms was 19.01 ± 17.77 days. The majority of patients had no history of trauma (89.7%) and had a single retinal break (77.9%). All lowest retinal breaks were located in the superior half of the retina, while 39.7% of the lowest retinal breaks were located in the superior 2 clock hours (11-1 o’clock). The mean extension of retinal detachment was 5.18 ± 2.44 clock hours. Most patients had PVR grade B (88.2%) and phakic lens (89.7%).

The rate of a single PR success was 42.6%. Preoperative characteristics were analysed to determine if any were predictors of pneumatic retinopexy outcome (Table 2). From all of these characteristics, only location of lowest retinal breaks and extension of retinal detachment were statistically significant predictors of pneumatic retinopexy outcome. In success group, majority of retinal breaks were detected at superior 2 clock hours (11-1 o’clock). The mean extension of retinal detachment was 5.18 ± 2.44 clock hours. Most patients had PVR grade B (88.2%) and phakic lens (89.7%).

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Moreover, the success rate of PR was 0.722 times when the extension of retinal detachment increased for 1 clock hour (OR=0.722, 95%CI 0.535-0.974, P=0.033).

Mean BCVA at 6 months was logMAR 0.391 compared to preoperative BCVA, that was logMAR1.255 (Figure 1). Out of the 29 patients from the success group, 27 (93%) patients had improvement of BCVA. There are several postoperative complications, which are new or missed break (12%), subconjunctival gas (10%), raised IOP (4%), Vitreous haemorrhage (3%) and subretinal gas (1%).

**Discussion**

PR is the treatment of choice for primary RRD, because it is more cost-effective than scleral buckling procedure and PPV. The success rate of PR is high, ranging from 43.75% to 93.55%. In this study, the success rate for a single PR was 42.6% of the cases. The lower success percentage may be due to small sample size or lesser experience of the technique.

This study showed that patients with pseudophakic/aphakic eyes were not significantly associated with PR failure. This was different from a previous study which demonstrated that PR was less successful in pseudophakic/aphakic eyes compared to phakic eye because of multiple tiny retinal break in periphery which may be missed.

Regarding the location of the lowest retinal breaks, superior 2 clock hours (11-1 o’clock) tended to achieve success PR significantly according to the study. It may be due to the postoperative positioning problem that patients with superior breaks can be easily postured than those with retinal breaks outside of 11-1 o’clock. Furthermore, the extension of retinal detachment was associated with success of PR. Larger extents of retinal detachment were more likely to result in failure of PR, consistent with previous literature.

In our study, mean BCVA at 6 months postoperative was logMAR 0.391 (Snellen equivalent ~20/50), which was consistent with literature, suggesting 80% of PR cases have 20/50 or better visual acuity. Several studies have discussed complications of PR. Some of them showed that cataracts was the most complication.
| Demographic Features                                    | n (%)       |
|---------------------------------------------------------|-------------|
| Mean age (years)                                        | 58.18 ± 8.79|
| Gender                                                  |             |
| Male                                                    | 33 (48.5%)  |
| Female                                                  | 35 (51.5%)  |
| Side of eye                                             |             |
| Right                                                   | 39 (57.4%)  |
| Left                                                    | 29 (42.6%)  |
| Mean duration of symptoms (days)                        |             |
| <7                                                      | 6 (8.8%)    |
| 7-27                                                    | 45 (66.2%)  |
| ≥ 28                                                    | 17 (25.0%)  |
| History of trauma                                       |             |
| Yes                                                     | 7 (10.3%)   |
| No                                                      | 61 (89.7%)  |
| Number of retinal breaks                                |             |
| Single                                                  | 53 (77.9%)  |
| Multiple                                                | 15 (22.1%)  |
| Location of lowest retinal breaks                       |             |
| 12,11,1                                                 | 27 (39.7%)  |
| 10,2,9,3                                                | 41 (60.3%)  |
| Mean RRD extension (clock-hour)                         | 5.18 ± 2.44 |
| PVR grade                                               |             |
| A                                                       | 8 (11.8%)   |
| B                                                       | 60 (88.2%)  |
| Macular status                                          |             |
| Macular on                                              | 21 (30.9%)  |
| Macular off                                             | 47 (69.1%)  |
| Lens status                                             |             |
| Phakic                                                  | 61 (89.7%)  |
| Pseudophakic/Aphakie                                     | 7 (10.3%)   |
Table 2: Ocular characteristics of successful versus failed cases

| Characteristics                        | success (n=29) | failure (n=39) | P-VALUE |
|----------------------------------------|---------------|----------------|---------|
|                                        | n  | %       | n   | %       |         |
| Age (y)                                |    |         |     |         | 0.095   |
| ≤60                                    | 20 | 69.0%   | 19  | 48.7%   |         |
| >60                                    | 9  | 31.0%   | 20  | 51.3%   |         |
| Mean ± S.D.                            | 55.83 ± 10.03| 59.92 ± 7.40 | 0.101* |
| Gender                                 |    |         |     |         | 0.132   |
| Male                                   | 11 | 37.9%   | 22  | 56.4%   |         |
| Female                                 | 18 | 62.1%   | 17  | 43.6%   |         |
| Side of eye                            |    |         |     |         | 0.418   |
| Right                                  | 15 | 51.7%   | 24  | 61.5%   |         |
| Left                                   | 14 | 48.3%   | 15  | 38.5%   |         |
| Mean duration of symptoms (days)       |    |         |     |         | 0.630f  |
| <7                                     | 2  | 6.9%    | 4   | 10.3%   |         |
| 7 - 27                                 | 18 | 62.1%   | 27  | 69.2%   |         |
| ≥ 28                                   | 9  | 31.0%   | 8   | 20.5%   |         |
| History of trauma                      |    |         |     |         | 0.721   |
| Yes                                    | 2  | 6.9%    | 5   | 12.8%   |         |
| No                                     | 27 | 93.1%   | 34  | 87.2%   |         |
| Number of retinal breaks               |    |         |     |         | <0.001* |
| Single                                 | 22 | 75.9%   | 31  | 79.5%   |         |
| multiple                               | 7  | 24.1%   | 8   | 20.5%   |         |
| Location of lowest retinal breaks      |    |         |     |         |         |
| 12,11,1                                | 21 | 72.4%   | 6   | 15.4%   |         |
| 10,2,9,3                               | 8  | 27.6%   | 33  | 84.6%   |         |
| RRD extension (clock-hour)             |    |         |     |         |         |
| Mean ± S.D.                            | 4.21 ± 2.01 | 5.90 ± 2.51 | 0.002* |
| PVR grade                              |    |         |     |         |         |
| A                                      | 4  | 13.8%   | 4   | 10.3%   |         |
| B                                      | 25 | 86.2%   | 35  | 89.7%   |         |
| Macular status                         |    |         |     |         | 0.278   |
| Macula on                              | 11 | 37.9%   | 10  | 25.6%   |         |
| Macula off                             | 18 | 62.1%   | 29  | 74.4%   |         |
| Lens status                            |    |         |     |         | 0.225f  |
| Phakic                                 | 28 | 96.6%   | 33  | 84.6%   |         |
| Pseudophakic/Aphakic                   | 1  | 3.4%    | 6   | 15.4%   |         |
| Pre-op BCVA (log MAR)                  |    |         |     |         |         |
| Mean ± S.D.                            | 1.26 ± 1.01| 1.62 ± 1.13| 0.162* |
| Pre-op Tension                         |    |         |     |         |         |
| Mean ± S.D.                            | 11.28 ± 3.32| 11.26 ± 4.09| 0.896* |
p-value from Chi-Square test, \( F = \) p-value from Fisher’s Exact Test, \( M = \) p-value from Mann-Whitney U test, * Significant at the 0.05 level

Table 3: Multivariate logistic regression analysis for successful group

| Characteristics                        | Adjusted Odds ratio | 95%CI       | P-VALUE |
|----------------------------------------|---------------------|-------------|---------|
| Location of the lowest retinal break   |                     |            |         |
| 12,11,1                                | 3.82- 48.01         | <0.001*     |         |
| 10,2,9,3                               | 13.55               |            |         |
| Reference                              |                     |            |         |
| RRD extension (clock hour)             | 0.722               | 0.535 -0.974| 0.033*  |

Table 4: Correlation of visual outcome with risk factors

| Characteristics                        | Success (n=29) | Improved (n=27) | VA Not improved (n=2) |
|----------------------------------------|----------------|-----------------|-----------------------|
|                                        | n %            | n %             | n %                   |
| Age (y)                                |                |                 |                       |
| ≤60                                    | 20 69.0%       | 20 74.1%        |                       |
| >60                                    | 9 31.0%        | 7 25.9%         | 2 100%                |
| Mean ± S.D.                            | 55.83 ± 10.03  | 54.93 ± 9.74    | 68.00 ± 5.66          |
| Gender                                 |                |                 |                       |
| Male                                   | 11 37.9%       | 9 33.3%         | 2 100%                |
| Female                                 | 18 62.1%       | 18 66.7%        |                       |
| Mean duration of symptoms (days)       |                |                 |                       |
| <7                                     | 2 6.9%         | 2 7.4%          |                       |
| 7 - 27                                 | 18 62.1%       | 17 63.0%        | 1 50.0%               |
| ≥ 28                                   | 9 31.0%        | 8 29.6%         | 1 50.0%               |
| History of trauma                      |                |                 |                       |
| Yes                                    | 2 6.9%         | 2 7.4%          |                       |
| No                                     | 27 93.1%       | 25 92.6%        | 2 100%                |
| Number of retinal breaks               |                |                 |                       |
| Single                                 | 22 75.9%       | 21 77.8%        | 1 50.0%               |
| Multiple                               | 7 24.1%        | 6 22.2%         | 1 50.0%               |
| Location of lowest retinal breaks      |                |                 |                       |
| 12,11,1                                | 21 72.4%       | 19 70.4%        | 2 100%                |
| 10,2,9,3                               | 8 27.6%        | 8 29.6%         |                       |
| RRD extension (clock hour)             |                |                 |                       |
| Mean ± S.D.                            | 4.21 ± 2.01    | 4.00 ± 1.33     | 7.00 ± 7.07           |
| PVR grade                              |                |                 |                       |
| A                                      | 4 13.8%        | 3 11.1%         | 1 50.0%               |
| B                                      | 25 86.2%       | 24 88.9%        | 1 50.0%               |
| Macular status                         |                |                 |                       |
| Macula on                              | 11 37.9%       | 10 37.0%        | 1 50.0%               |
| Macula off                             | 18 62.1%       | 17 63.0%        | 1 50.0%               |
### Lens status

| Lens status | Phakic | Aphakic |
|-------------|--------|---------|
| Count       | 28     | 1       |
| Percentage  | 96.6%  | 3.4%    |

### Preop BCVA (log MAR)

| Mean ± S.D. | 1.26 ± 1.01 | 1.24 ± 0.96 | 1.50 ± 2.12 |

| Preop Tn     | 11.28 ± 3.32 | 11.67 ± 3.04 | 6.00 ± 2.83 |

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**Figure 1:** Functional outcomes of eyes in successful pneumatic retinopexy group

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Previous study? They proposed that early new retinal breaks and RD developed due to traction on condensed vitreous distal to the sites of the original breaks following intraocular gas injections. Approximately 76% of new or missed breaks are located in the superior clock hours of the retina, and 52% are found within 3 clock hours of the pre-existing causative breaks. Giant retinal tears rarely develop following pneumatic retinopexy.

Nonetheless, there were some limitations to our study. The retrospective design did not yield additional information which can influence the outcomes. The sample size was insufficient to define the associated factors between improved visual outcome and maintained visual outcome group. Moreover, different surgeons may have different levels of capabilities which may influence outcomes.

**Conclusion**

PR is a minimally invasive, low-cost and well tolerated treatment modality. PR offers distinct advantage for primary RRD over scleral buckling procedure and PPV, provided there is adequate patient selection. The rate of a single PR success in this study was 42.6% of patients. Our study results suggested that characteristics which were most likely to have benefit from PR were retinal breaks located in the superior 2 clock hours and smaller extensions of retinal detachment. Final BCVA was improved in most patients with successful PR.
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