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CLINICAL STUDY

Pneumodescemetopexy with perfluoroethane (C_2F_6) for the treatment of acute hydrops secondary to keratoconus

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Abstract

Purpose **To evaluate the efficacy and safety of pneumodescemetopexy with intracameral perfluoroethane (C_2F_6) gas for the treatment of acute hydrops secondary to keratoconus.**

Methods **Retrospective, non-comparative, interventional case series. Eight eyes of eight patients who presented with acute hydrops secondary to keratoconus between July 2009 and September 2013 were consecutively recruited. All were treated with intracameral 14% isoexpansile concentration of C_2F_6. Preoperative and postoperative best-corrected visual acuities (BCVA), intraoperative and postoperative complications, and time taken for resolution of corneal oedema were assessed.**

Results **All the patients, except for one, were followed up for 1 year. The mean age of the cohort was 29.1 ± 13.5 years. BCVA at presentation was 6/60 or less in all patients. Improvement of BCVA was achieved postoperatively in seven (87.5%) patients, with three (37.5%) patients achieving a BCVA of 6/18. The average time between initial presentation and complete resolution of corneal oedema was 60.0 ± 32.1 days. The C_2F_6 gas persisted in the anterior chamber between 6 and 8 days. All the patients required only one injection during the treatment period. There was no intraoperative or postoperative complication noted during the follow-up period.**

Conclusion **Pneumodescemetopexy with intracameral isoexpansile concentration of C_2F_6 gas serves as a safe and effective treatment modality for patients with acute hydrops secondary to keratoconus.**

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Introduction

Acute corneal hydrops is an uncommon but well-recognised complication in patients with keratoconus. It is caused by a rupture in the Descemet's membrane leading to influx of aqueous into the corneal stroma resulting in corneal oedema. During the attack, patients typically experience pain, photophobia, watery eye, and decrease in visual acuity. It has been shown that young male patients with poor vision at diagnosis of keratoconus and history of severe allergic eye disease are more likely to develop acute hydrops.[1]

Conventionally, acute hydrops is treated medically with topical antibiotic, hypertonic saline, cycloplegic with or without a bandage contact lens. However, there is emerging evidence suggesting that an earlier resolution of corneal oedema could be facilitated by intracameral injection of air,[2] sulphur hexafluoride (SF_6)[3,4] and perfluoropropane (C_3F_8) gas.[5–7] The proposed mechanism is that the intracameral air or gas acts as a mechanical tamponade, helping the apposition of the Descemet's membrane and creating a barrier to prevent the entry of aqueous into the cornea. However, each of these intracameral substitutes has its inherent problems. For instance, the short-acting property of intracameral air or SF_6 gas injection can lead to premature disappearance of the gas resulting in inadequate treatment of the acute hydrops.[2–4] This means that additional intracameral injection is required to maintain its tamponading action.

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On the other hand, C_3F_8 a longer-acting agent than SF_6 and air has shown to be effective in treating acute hydrops; however, there is a concern about the risk of pupillary block causing secondary glaucoma.[7,8]

Lincoff *et al*[9] compared the intravitreal longevity of the perfluorocarbons and showed that carbon tetrafluoride had the longevity characteristics similar to those of SF_6 gas, whereas perfluoroethane (C_2F_6) persisted 2.6 times longer than SF_6 and C_3F_8 remained approximately four times longer. Perfluorocarbon of intermediate duration (ie, C_2F_6) may have an advantage over SF_6 and C_3F_8 gases and could potentially address the short-acting property of SF_6 gas and the risk of pupillary block and potential cataract formation encountered with C_3F_8 gas.

We had previously reported our experience in managing a case of bilateral acute hydrops secondary to keratoglobus with C_2F_6 gas.[10] Herein, we report a small cohort of patients with acute hydrops secondary to keratoconus that were successfully treated with intracameral C_2F_6 gas.

Materials and methods

This study was a retrospective, non-comparative, interventional case series. All the patients who presented to the corneal service at the University Hospital Ayr, Ayr, Scotland, UK with acute corneal hydrops secondary to keratoconus between July 2009 and September 2013 were consecutively recruited. Acute hydrops was defined as the sudden onset of corneal oedema secondary to rupture of the Descemet's membrane. All the patients underwent a comprehensive ophthalmic examination, including best-corrected visual acuity (BCVA), slit-lamp biomicroscopy, Goldmann tonometry, pachymetry, and dilated fundal examination. Anterior segment optical coherence tomography (AS-OCT) was performed in six patients. Diagnosis of acute hydrops was confirmed with slit-lamp biomicroscopy and pachymetry in all patients and with additional AS-OCT in six patients.

Surgical procedure

Informed consent was obtained in all the patients before the procedure. All the cases were operated within a week of initial presentation of acute hydrops. Surgery was carried out in the operating room under topical or general anaesthesia by a corneal surgeon (SS). Preoperatively, a drop of 2% pilocarpine (Minims, Chauvin Pharmaceuticals, Romford, England) was instilled to constrict the pupil with the view of preventing any iatrogenic trauma to the crystalline lens. Under aseptic condition, a 27-gauge needle was used to create a paracentesis. The posterior lip of the paracentesis was gently depressed with the needle to release a small amount of aqueous. A 30-gauge needle mounted on a 2 ml syringe was used to inject 1 ml of an isoexpansile concentration (14%) of C_2F_6 gas through a fresh peripheral corneal wound into the anterior chamber to obtain a full gas fill of the anterior chamber. At the end of the procedure, the patient received 500 mg of intravenous acetazolamide and one drop of 0.5% chloramphenicol (Minims, Chauvin Pharmaceuticals) was placed in the inferior conjunctival sac. Postoperatively, all the patients were instructed to lie in a supine position for around 4 to 6 h. All the patients received topical ofloxacin eye drops (Exocin, Allergan, Irvine, CA, USA) four times a day for 2 weeks. No other topical medications, including steroids, hypertonic saline, and anti-glaucomatous drops, were used pre and postoperatively. All were examined at 1 day, 1 week, and 4 weeks time gate and monthly thereafter till resolution of corneal oedema was noted. Slit-lamp biomicroscopy combined with Goldmann tonometry and pachymetry were performed during each postoperative visit. Resolution of acute hydrops was confirmed with slit-lamp biomicroscopy and pachymetry in all patients and with additional AS-OCT in six patients. All the patients were followed up for 1 year, except for one patient who had so far attended her 6th month follow-up.

Results

A total of eight patients were recruited during the study period: four (50%) were male and the mean age of the cohort was 29.1 ± 13.5 years. Demographic factors, clinical details and time taken for complete resolution of corneal oedema from initial presentation are detailed in Table 1. All the eight patients had a presenting BCVA of 6/60 or less. Improvement of BCVA was observed in seven (87.5%) patients postoperatively, with three (37.5%) of them having a BCVA of 6/18. The average time between initial presentation and complete resolution of corneal oedema was 60.0 ± 32.1 days. All the patients received only one injection during the entire treatment period. The C_2F_6 gas persisted in the anterior chamber between 6 and 8 days. There was no intraoperative or postoperative complication noted. In particular there was no case of increased intraocular pressure or secondary angle closure glaucoma. Preoperative and postoperative clinical and AS-OCT appearances of one of our patients (case number 5) were illustrated in Figure 1.

Discussion

Acute hydrops is a well-recognised complication in patients with keratoconus. The reported overall

Table 1 Demographic factors, clinical and surgical details of all the eight patients

Patients	*Age (years)*	*Sex*	*Eye*	*Diagnosis*	*Preop BCVA*	*Postop BCVA*	*Time for resolution of hydrops (months)*	*Complication*	*Number of injections*
1	27	Female	Right	Keratoconus + learning difficulty	6/60	6/36	1	None	1
2	17	Male	Right	Keratoconus + Down syndrome	CF	6/60	2	None	1
3	32	Male	Left	Keratoconus + Down syndrome	4/60	6/60	4	None	1
4	39	Female	Left	Keratoconus	CF	6/18	3	None	1
5	18	Male	Left	Keratoconus	CF	6/18	2	None	1
6	10	Female	Left	Keratoconus + Leber's congenital amaurosis	CF	CF	2	None	1
7	49	Female	Left	Keratoconus	6/60	6/36	1	None	1
8	39	Male	Right	Keratoconus	CF	6/18	1	None	1

Abbreviations: BCVA, best-corrected visual acuity; Postop, postoperative; Preop, preoperative.

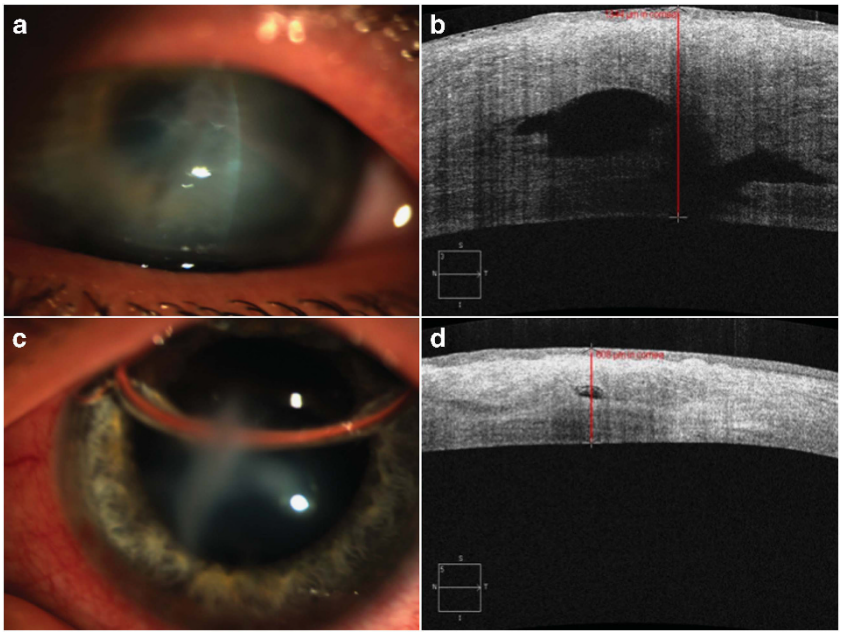

Figure 1 (a) Clinical photograph of patient number 5 showing severe corneal oedema secondary to acute hydrops involving the left eye. (b) Anterior segment optical coherence tomography (AS-OCT) of the left eye (patient number 5) showing severe corneal oedema, with intrastromal pockets of fluid. The corneal thickness was measured at 1344 microns. (c) Clinical photograph taken at day 3, following pneumodescemetopexy, showing resolution of cornea oedema. Note the residual gas bubble in the anterior chamber. (d) Post injection AS-OCT showing resolution of corneal oedema with a small residual intrastromal fluid pocket. The corneal thickness was measured at 608 microns.

prevalence of acute hydrops in keratoconus is around 2–3%.[7,11] Despite its self-limiting nature, the time for resolution of corneal oedema may take up to 36 weeks when managed conventionally with topical medications with or without bandage contact lens.[12] Prolonged corneal oedema can potentially increase the risk of corneal neovascularisation, which is a significant risk factor for graft rejection, microbial keratitis, and corneal perforation.[7,13,14] Feder *et al*[13] reported that six (66.7%) of their patients with acute hydrops developed stromal neovascularisation when managed with topical medications. Also, acute hydrops typically affects the younger patients, posing negative impacts on the economy and the patient's quality of life. Therefore, treatment modalities that can expedite the resolution of corneal oedema are beneficial.

The use of intracameral injection of air or gas is not an entirely new concept. In 1987, Zusman *et al*[15] first described the use of gas exchange or 'pneumodescemetopexy' to repair intraoperative Descemet's membrane detachment. The proposed mechanism was that the gas acts as a mechanical tamponade preventing the imbibition of the aqueous into the cornea and hence a faster resolution of corneal oedema.

Table 2 Overview of the treatment, clinical outcomes and complications of various studies in relation to the treatment of acute hydrops

Authors	N	*Treatment*	*Mean healing time (days) Treated group vs control group*	*Repeated injections (eyes)*	*Complications*
Miyata *et al*[2]	9	IC Air	20.1 ± 9.0 *vs* 64.7 ± 34.6	7 (77.8%)	None
Panda *et al*[3]	9	IC SF_6	Not mentioned	6 (66.7%)	None
Rajaraman *et al*[6]	17	IC C_3F_8 + CS	8.9 ± 4.9 *vs* N/A	None	None
Basu *et al*[7]	62	IC C_3F_8	90.5 ± 55.8 *vs* 125 ± 68.9	None	Glaucoma (10, 16%)
Sharma *et al*[16]	14	IC C_3F_8	Not mentioned	5 (35.7%)	Glaucoma (2, 14%); intrastromal gas migration (2, 14%)
Present study	8	IC C_2F_6	60.0 ± 32.1 *vs* N/A	None	None

Abbreviations: CS, compression suture; C_2F_6, perfluoroethane; C_3F_8, perfluoropropane; IC, intracameral; N, number of treated eyes; N/A, not available; SF_6, sulphur hexafluoride.

Miyata *et al*[2] reported a faster resolution of corneal oedema in patients with acute hydrops secondary to keratoconus with intracameral injection of air in comparison with the control group that was treated conventionally with topical medications. However, repeated injections were required in as many as seven (77.8%) patients (Table 2). Similarly, shorter resolution time was observed in Panda *et al*[3] study with the use of intracameral SF_6 gas; however, six (66.7%) patients required repeated injections. This has prompted the idea of using a longer-acting agent like C_3F_8 gas to prolong the mechanical tamponading action in the anterior chamber.[6,7,16] Rajaraman *et al*[6] and Basu *et al*[7] both reported that single injection of intracameral C_3F_8 gas was sufficient to treat the acute hydrops whereas Sharma *et al*[16] reported that five (35.7%) of their patients required repeated injections of intracameral C_3F_8 gas. One of the major complications of intracameral C_3F_8 gas is the risk of secondary glaucoma.[7,8,16] Basu *et al*[7] reported that as high as 16% of the treatment cohort developed pupillary block postoperatively, necessitating an additional iridectomy to prevent or treat the complication.

Taking into consideration the duration of action of the intracameral gas injection and the risk of complication, particularly secondary glaucoma, we advocated the use of C_2F_6 gas, which is an intermediate-acting agent compared with SF_6 and C_3F_8 gas. In our case series, none of the patients developed any intraoperative or postoperative complication. In addition, all our patients required only one injection of intracameral C_2F_6 gas during the treatment period.

The average time taken for complete resolution of corneal oedema from initial presentation was 60.0 ± 32.1 days. Although the healing time in our study was longer than the results reported in some other studies,[2,6] it was comparable with the data presented by Basu *et al*,[7] which was the largest study in relation to the treatment of acute hydrops. Basu *et al*[7] reported a mean healing time of 90.5 ± 55.8 days in the treatment group as compared with 125 ± 68.9 days in the control group. Future randomised controlled trials will help elucidate the absolute effectiveness of intracameral C_2F_6 gas.

There is some debate whether the BCVA of subjects affected with corneal hydrops is influenced by the intervention they had for managing the corneal hydrops. The aim of the intracameral gas injection is to reduce the duration of oedema thus minimising the secondary effects like stromal vascularisation and scarring. Panda *et al*[3] reported that BCVA of the treatment group was significantly better than the control group at the 12th week postoperatively. Although similar result was not observed in other studies,[2,7] Basu *et al*[7] reported that patients who had intracameral gas injection were less likely to require further keratoplasty for visual rehabilitation, suggesting that faster resolution of corneal oedema might have a positive impact on visual acuity. The final BCVA is greatly influenced by the position and the amount of scarring in relation to the visual axis, which might explain the heterogeneity of the results reported in various studies. We observed that seven (87.5%) of our patients achieved improvement in the final BCVA following treatment. The only patient who did not achieve any improvement in the final BCVA following treatment suffered from co-existing Leber's congenital amaurosis, which could be accountable for the poor vision following resolution of the corneal oedema.

We acknowledged that our study was limited by its retrospective nature, small sample size, and the lack of control group. Nonetheless, our experience suggested that intracameral C_2F_6 serves as a safe and effective treatment modality in managing patients with acute hydrops secondary to keratoconus. Future studies directly comparing the safety and efficacy of different intracameral gas injections will be useful.

Summary

What was known before

- Intracameral air or gas injection can expedite the resolution of acute hydrops by serving as a mechanical barrier, which helps in the apposition of Descemet's membrane and prevents aqueous influx into the cornea.
- Air and sulphur hexafluoride (SF6) gas have short duration of action and perfluoropropane (C3F8) gas is associated with risk of secondary glaucoma.

What this study adds

- Intracameral perfluoroethane (C2F6) gas serves as a safe and effective treatment modality in managing acute hydrops secondary to keratoconus.
- No complication was identified during intra- or post-operative period.
- Only one injection is required for each patient during the entire treatment period.

Conflict of interest

The authors declare no conflict of interest.

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