Case Series

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Transcutaneous oxygen tension-guided hyperbaric oxygen therapy for preventing skin necrosis after hyaluronic acid filler injections

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Introduction: Hyaluronic acid (HA) fillers, popular for facial cosmetic enhancements, pose risks of vascular complications like skin necrosis due to arterial blockage, necessitating effective treatments such as hyperbaric oxygen therapy (HBOT).

Methodology: This study presents a series of cases where measurements of transcutaneous oxygen pressure ($TcPO_2$) informed the application of HBOT for skin necrosis induced by HA.

Clinical presentation and outcomes: In cases 1 and 3, following the injection of HA, potential skin necrosis was observed. In addition to standard treatment, $TcPO_2$ revealed values below 40 mmHg, indicating tissue hypoxia. Treatment with HBOT increased $TcPO_2$ levels to above 200 mmHg, suggesting that HBOT could correct the hypoxia. Monitoring $TcPO_2$ levels also aided in determining the optimal time to discontinue HBOT. In cases 2 and 4, patients received standard treatment, resulting in $TcPO_2$ levels above 40 mmHg, indicating adequate tissue oxygenation, and no additional HBOT was administered. All four patients mentioned above showed good clinical recovery.

Conclusion: This study investigates the application of $TcPO_2$ measurement technology in aiding decisions on whether to utilize HBOT in the treatment of complications arising from HA fillers, as well as in optimizing HBOT protocols.

Keywords: hyaluronic acid filler injections, hyperbaric oxygen therapy, transcutaneous oxygen tension, vascular complications

Introduction

Hyaluronic acid (HA) has become increasingly popular as a filler material for injection, especially in facial areas with high blood flow such as the nasolabial angle, nasal structures, and the lips. These injections are typically administered into the deep layers of the skin, including the deep subcutaneous fat layer, subdermal, and deep dermal layers, where major blood vessels are located[1]. Despite the high level of skill possessed by injectors, vascular complications, though rare, can occur. One of the most severe complications is skin necrosis, which results from arterial obstruction or compression, leading to ischemic damage[2].

Hyperbaric oxygen therapy (HBOT) has been recognized as an effective treatment for enhancing tissue oxygen partial pressure in various anoxic wound scenarios, including diabetic foot ulcers and avascular necrosis[3]. HBOT is receiving increased attention for its potential in treating vascular complications in cosmetic surgery, although its application in this field still does not match its widespread use for conditions like diabetic foot ulcers. For instance, the approach to HBOT for diabetic foot ulcers, which includes predicting the effectiveness of HBOT and determining the duration of treatment, benefits not only from the clinical experience but also from objective assessments like transcutaneous oxygen and ultrasound measurements. These can facilitate a more refined, personalized approach to HBOT[4]. Currently, the use of HBOT to address skin necrosis caused by HA fillers primarily relies on clinical symptoms, such as color changes and absent capillary refill, to indicate ischemia[1,2]. In this context, we investigated the use of transcutaneous oxygen tension ($TcPO_2$) measurements to assist in determining the appropriate HBOT pressure and intervention duration for skin necrosis following HA filler injections.

HIGHLIGHTS

- Currently, the hyperbaric oxygen therapy (HBOT) application for treating vascular complications caused by hyaluronic acid filler injections lack standardized objective indicators and often depend on clinical experience.
- Transcutaneous oxygen pressure can indicate the degree of hypoxia in wounds and whether HBOT may correct this hypoxia.
- Transcutaneous oxygen pressure provides objective indicators to assist in decision-making regarding the implementation of HBOT for hyaluronic acid complications.

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Methodology

The study is a case series. Research registration unique identifying number (UIN) is not required for the case series. Four patients with HA-induced skin necrosis were recruited between November 2022 and December 2023 in a teaching hospital in Beijing, China. The detailed demographic, clinical, and management information was collected accordingly. The clinical data of each patient mentioned above were assessed and documented by two dermatologic surgeons and two experienced hyperbaric oxygen therapists. The cases were kept on follow-up wherever possible. All procedures were followed with the ethical standards of the institutional research committee, the 1964 Helsinki Declaration, and its later amendments or comparable ethical standards. Written informed consents were obtained from the patients for the publication of this case series with accompanying images. The doctors and patients participating in the study received no financial incentives. This case series is reported in line with the preferred reporting of case series in surgery (PROCESS) guideline[5].

Cases presentation

Case 1

A 24-year-old man underwent HA injections in the dorsum and columella of his nose, as well as in his nasolabial folds, with no prior history of allergies. Each injection consisted of 1.5 ml of HA at 20 mg/ml mixed with 0.3 ml of 1% lidocaine, totaling 18 ml of the HA-lidocaine mixture. The injections were distributed across eight points including the glabellum, columella, nasal dorsum, nasal root, and nasal tip. The injector was unsure about the injection depths. The patient experienced pain in the glabellum area during the procedure. Swelling around the glabellum and left orbit, along with tenderness, emerged 2 h postinjection, followed by macular skin changes around the nose, left eye, and forehead after 4 h. Six hours after the injection, the injector attempted to alleviate skin tension by acupuncturing the swollen areas around the glabellum and nose with a blunt needle, which did not relieve symptoms and led to aggressive worsening within 24 h. The macular skin changes and swelling extended to the bilateral nasolabial sulcus, the entire nose, eyebrows, and forehead, with imminent skin necrosis on the left nasal ala, forehead, and inner canthus. The patient was admitted to a cosmetic clinic on the following day (Day 2), receiving 1000 U of hyaluronidase in both the left nasal root and glabellum, and was treated with prednisolone, aspirin, cefuroxime, and alprostadil. No symptoms of dizziness, headache, fever, vision decline, or dyskinesia were observed. Although the imminent skin necrosis on the left inner canthus was alleviated, swelling worsened.

Three days after the initial HA injections (Day 4), the patient presented to the HBOT unit with severe swelling in the nose, eyes, and forehead, two areas of obvious skin necrosis on the left nasal ala and left eyebrow, and three areas of imminent skin necrosis on the right nasal ala, forehead, and left inner canthus (Fig. 1). $TcPO_2$ in the forehead was 28 mmHg, indicating hypoxia. $TcPO_2$ increased to 114 mmHg after 100% oxygen inhalation at normal baric atmosphere and reached 211 mmHg under 0.24 MPa 100% oxygen, implying the hypoxic wound could benefit from HBOT according to the certification of HBOT. HBOT commenced on Day 5, and the HBOT protocol involved 90 min of 100% oxygen at 0.24 MPa. $TcPO_2$ in the forehead was 34 mmHg in air at normal baric atmosphere, 161 mmHg under 100% oxygen at normal baric atmosphere, and 291 mmHg under 100% oxygen at normal baric atmosphere, reaching 351 mmHg under 0.24 MPa 100% oxygen on Day 8. The following HBOT continued from Day 8 to Day 15. The swelling and skin necrosis were significantly relieved after 14 HBOT sessions (Fig. 2) and $TcPO_2$ was 61 mmHg in air at normal baric atmosphere, indicating that the wound was no longer hypoxic, leading to the discontinuation of HBO. The wounds had healed, and the patient was satisfied with the outcome after 30 days (Fig. 3).

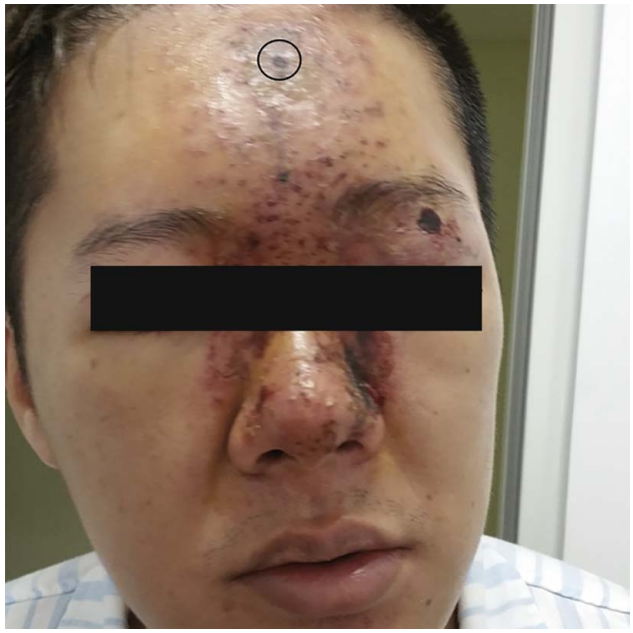

Figure 1. Three days after the initial hyaluronic acid injection.

Case 2

A 28-year-old woman, with a history of HA injections in her chin 10 months prior, received a 3 ml HA injection in her columella and nasal dorsum, 3 ml in her chin, and 1.5 ml in her forehead. She developed painless, reticulated, edematous purpuric plaques on her nasal tip, nasal ala, glabellum, columella, nasal dorsum, nasal root, and part of her forehead, as well as ecchymosis in her chin within 12 h (Fig. 4). Hot compresses were applied to the affected areas and after receiving hyaluronidase injections at the base of the columella, she consulted the HBOT unit on Day 2. $TcPO_2$ measured at the nasal tip by an experienced practitioner was 58 mmHg in a normal baric atmosphere. HBOT was not administered as the wound was not considered ischemic, with $TcPO_2$ above 40 mmHg. The patient was treated with fusidic acid, prednisolone, and aspirin for 1 week. By Day 4, $TcPO_2$ had increased to 67 mmHg. By Day 7, the purpura, erythema, and erosion had completely resolved (Fig. 5).

Case 3

It involves a 30-year-old woman who underwent a 2 ml HA gel injection for enhancement of her upper lip. Immediately following the procedure, her upper lip discolored, suggesting an occlusion in the buccal branch of the maxillary artery. Two hours

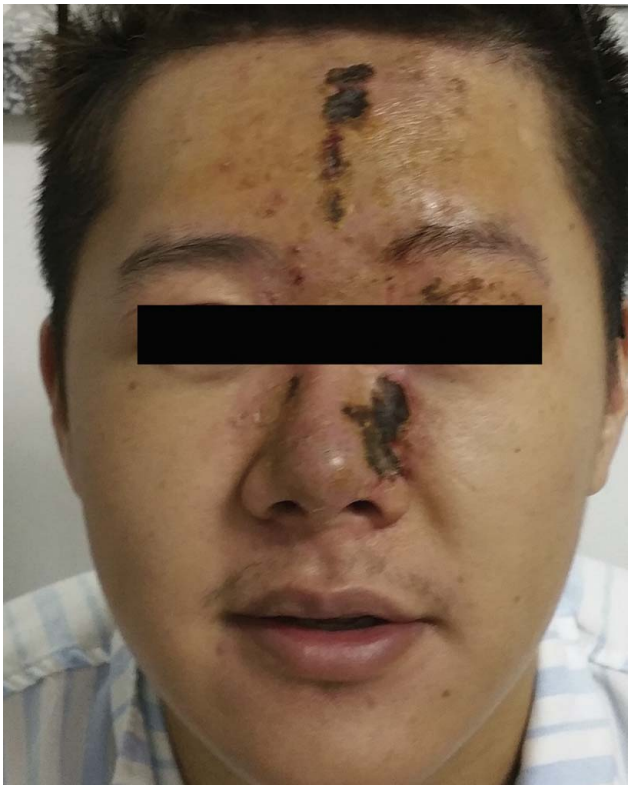

Figure 2. After 14 times of hyperbaric oxygen therapy.

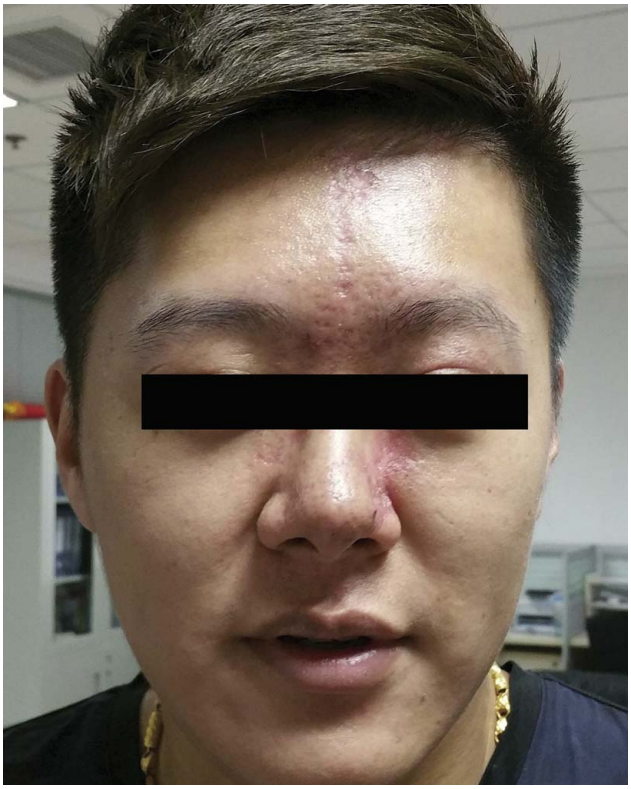

Figure 3. Wounds recovered 30 days later.

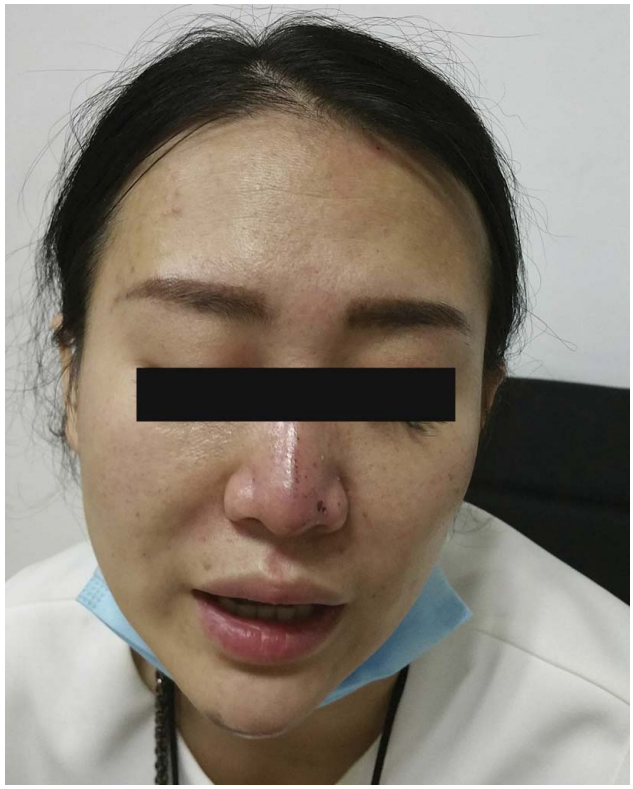

Figure 4. One day after hyaluronic acid injection.

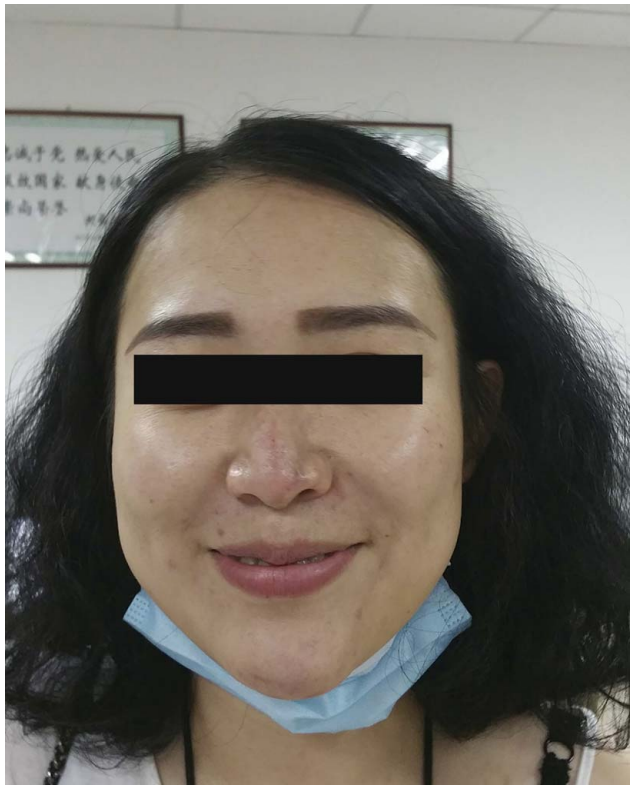

Figure 5. Seven days after hyaluronic acid injection.

postinjection, she was treated with hyaluronidase injections in her upper lip and at the base of her columella, due to the suspicion of the filler being inadvertently injected into an artery. Eight hours after the initial injection, she presented to the HBOT unit with her right upper lip appearing black and swollen (Fig. 6). At this time, her $TcPO_2$ was 31 mmHg while breathing air. This level increased to 125 mmHg upon breathing 100% oxygen and further escalated to 263 mmHg following HBOT at 0.24 MPa. She received a total of five HBOT sessions at 0.2 MPa, one session daily from Day 1 to Day 5. By the fifth day, her $TcPO_2$ had improved to 44 mmHg on room air, leading to the discontinuation of HBOT. By the 10th day, the purpura and blackening had significantly improved, leaving her with no obvious cosmetic defects (Fig. 7).

Case 4

A 36-year-old woman received 3 ml of HA injections in various areas of the left nasal ala without preinjection local anesthesia, experiencing mild pain during the procedure. Twenty-five minutes postinjection, a livedo reticularis pattern developed on the left side of her face, extending from the radix of the nose to the tip and left nasal ala. Hyaluronidase was administered to the affected areas, and the patient was monitored for 5 h. Some mottling persisted, prompting further superficial hyaluronidase injections into the dorsum of the nose. Two days after the second hyaluronidase treatment, the patient was referred to the HBOT unit, with her condition depicted in Figure 8. $TcPO_2$ in the left nasal ala was 51 mmHg in a normal baric atmosphere. HBOT was not pursued. The patient was discharged with aspirin and antibiotics.

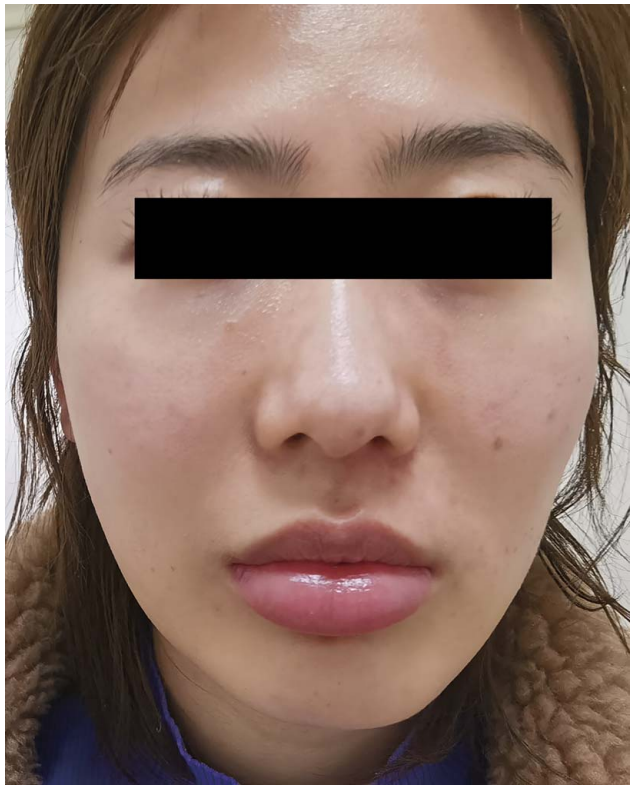

Figure 7. On day 10; after 5 dives of hyperbaric oxygen therapy.

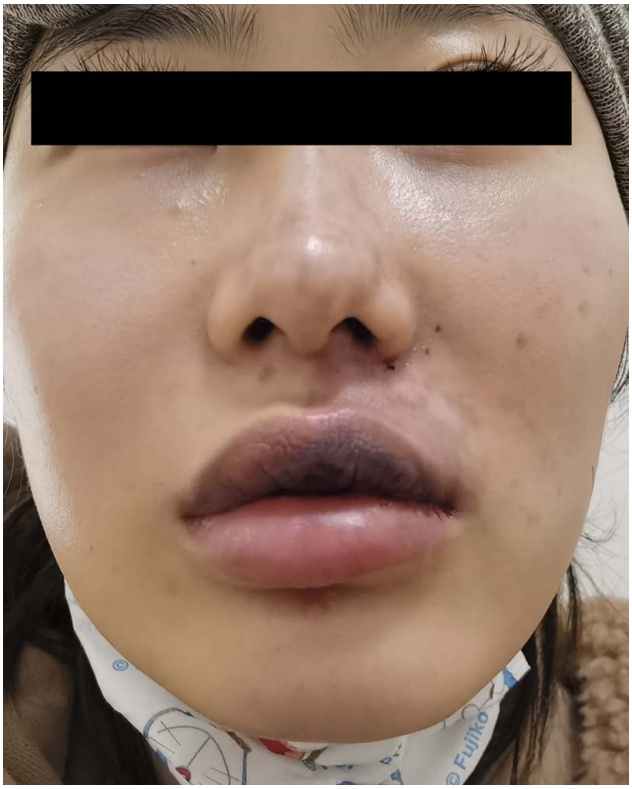

Figure 6. Eight hours after hyaluronic acid injection.

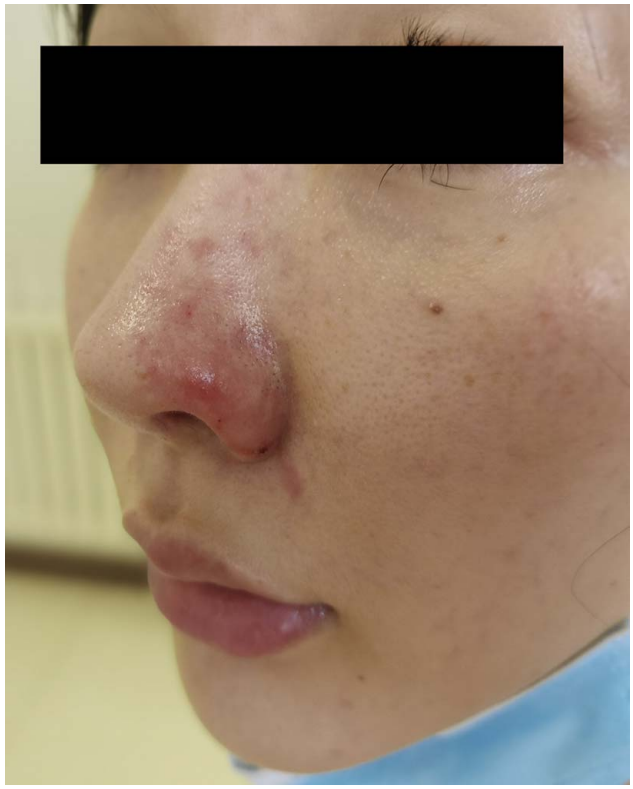

Figure 8. One day after hyaluronic acid injection.

Twenty days post-HA injection, the bruise had healed without any residual scarring (Fig. 9).

Discussion

HA injections represent a minimally invasive cosmetic procedure that has gained popularity in recent years. While adverse outcomes from HA fillers are uncommon, their incidence might rise as the use of these fillers expands. Injection-induced necrosis stands as one of the most critical complications associated with dermal fillers, primarily resulting from vascular interruption due to either the intravascular placement of the injection or external compression of nearby vessels. Typically, superficial skin damage or erosion might suggest venous occlusion, whereas more profound erosion or ulceration could indicate arterial blockage[1,2]. Multiple treatment options (e.g. frequently massaging the affected area, warm compresses, hyaluronidase, aspirin, nitroderm paste, and anticoagulants, etc.) have been used to treat these complications. Given the role of HBOT in correcting hypoxia, its application as an adjunct therapy for skin necrosis caused by HA injections has also gained research interest[1,2,5]. To our knowledge, there are currently about a dozen studies on HBOT for injection complications[6–11]. However, these papers provide relatively less detail regarding the monitoring of the effectiveness of HBOT and the duration of HBOT.

$TcPO_2$ has been relatively well-established in assessing the degree of hypoxia in diabetic foot ulcers[12]. In using $TcPO_2$ for diabetic foot applications, the detection threshold is set at 40 mmHg. When the $TcPO_2$ level is below 40 mmHg while breathing air, it indicates the wound is hypoxic. Conversely, when the level is above 40 mmHg under the same conditions, it suggests the wound is nonhypoxic. For patients with hypoxic wounds, identified by $TcPO_2$ levels below 40 mmHg while breathing air, $TcPO_2$ levels are measured again during HBOT. If HBOT can increase $TcPO_2$, it indicates HBOT can effectively correct wound hypoxia. If HBOT intervention cannot correct wound hypoxia, it may be necessary to consider whether the wound has necrotized or if vascular issues are present[13]. Its values also serve as effective indicators for determining the suitability of HBOT for diabetic feet, as well as for guiding the selection of the start and end of the HBOT[14]. This study exploratorily applies $TcPO_2$ for decision-making in the adjunctive HBOT of HA-induced skin necrosis. In patients of case 1 and case 3, we measured $TcPO_2$ levels below 40 mmHg, indicating hypoxia, and we administered HBOT. In contrast, for case 2 and case 4, we measured levels above 40, suggesting no severe hypoxia, and we did not administer HBOT. Additionally, by dynamically monitoring changes in patients' $TcPO_2$, we determined the course of HBOT; for instance, case 1 received 14 sessions of HBOT, while case 3 received 5 sessions. In case 3, after five sessions of HBOT, the oxygen deprivation issue was resolved, as evidenced by the normalization of the $TcPO_2$ level to above 40 mmHg on room air. Thus, it was not deemed necessary to continue with the HBOT. From this perspective, $TcPO_2$ may assist in more accurately determining the personalized treatment course for patients undergoing HBOT, thereby reducing the costs associated with HBOT.

Figure 9. Twenty days after hyaluronic acid injection.

Studies indicate that flap blood flow blockage within 5 h causes dilated capillaries, swollen cell mitochondria, and reversible vessel wall thrombosis. If blocked over 7 h, damage becomes severe and partly irreversible[15]. Cases 1 and 2 revealed residual scarring indicative of eventual irreversible tissue loss despite the treatment. We speculated that the delayed treatment of these two cases of HA complications may have been the cause. A prompt response to complications from HA requires administering a regimen that includes steroids, antibiotics, antivirals, 1% nitroglycerin, antihistamines, aspirin, hot compresses, and HBOT. Further research is needed to optimize the role of HBOT in treatment and its synergy with alternative therapies.

Our research is limited, especially due to the small number of cases and lack of randomized controlled trials. Furthermore, the guidance of hyperbaric oxygen intervention in the treatment of complications in HBOT needs further exploration, particularly in relation to the data correlation between transcutaneous oxygen partial pressure results and other indicators such as vascular Doppler ultrasound.

Conclusion

Although this article only presents four cases, these cases demonstrate the potential for using $TcPO_2$ to guide HBOT after vascular embolization or occlusion following HA injection. Whether this approach is feasible still requires further clarification through additional randomized controlled studies.

Ethical approval

Ethical approval for this study (Ethical Committee N°HZKY-PJ-2022-57) was provided by the Medical Ethics Committee of General Hospital of PLA, Beijing, China on 26 May 2022.

Consent

Written informed consent was obtained from the patient for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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Author contribution

Q.Y.: contributed to data collection; Z.S.: contributed to data collection and data analysis; S.P.: contributed to writing the paper; H.L.: contributed to study concept and data analysis.

Conflicts of interest disclosure

The authors report no conflicts of interest.

Research registration unique identifying number (UIN)

None.

Guarantor

Hang Li.

Data availability statement

All data analyzed are available in the manuscript.

Provenance and peer review

This paper was not invited.

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