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# Impact of Hyperbaric Oxygen Therapy in the Postoperative Period of Plastic Surgery

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## ABSTRACT

Hyperbaric Oxygen Therapy (HBOT) has emerged as a promising adjuvant strategy to optimize the postoperative course in plastic surgery, particularly regarding wound healing, flap survival, and the reduction of complications such as necrosis and infection. Common aesthetic procedures such as abdominoplasties, liposculptures, and rhytidectomies present complication rates ranging from 10% to 15% in the absence of HBOT, leading to prolonged hospital stays and increased healthcare costs. HBOT, by delivering 100% oxygen at pressures between 1.4 and 2.8 ATA, raises Tissue Oxygen Partial Pressure ($PtO_2$) to levels exceeding 1,000 mmHg, ensuring adequate oxygen supply even to hypoxic areas and activating molecular repair mechanisms. Retrospective clinical studies and recent meta-analyses indicate significant reductions in adverse events when HBOT is used prophylactically. In liposculpture and abdominoplasty, 10-session protocols at 2.0 ATA reduced complications from 14% to 10.7% and eliminated surgical wound infections. In rhytidectomies, patients undergoing HBOT had an average healing time of 13.3 ± 3.1 days compared to 36.9 ± 9.4 days in the control group, with postoperative hematomas virtually eliminated. In immediate post-mastectomy breast reconstruction, flap salvage rates increased from 65% without HBOT to 88% with HBOT, and reoperation rates dropped from 27% to 9% in irradiated patients. On a cellular and molecular level, intermittent hyperoxygenation inhibits pro-inflammatory cytokines (IL-1β, TNF-α) and stimulates angiogenic growth factors (VEGF, FGF-2, TGF-β1), enhancing fibroblast proliferation and collagen deposition. In vitro assays show up to 1.8-fold increases in cell proliferation at 2.4 ATA, accelerating early tissue repair phases. From an economic standpoint, although each HBOT session incurs direct costs, analyses indicate up to five days of reduced hospitalization and fewer surgical revisions, making the protocol potentially cost-effective for complex surgeries. The safety profile is favorable, with a very low incidence of severe adverse events (<0.1%) and mild complications (otalgia, barotrauma) in less than 5% of cases. However, heterogeneity in therapeutic parameters (pressure, number of sessions, timing) and the scarcity of multicenter randomized trials limit clinical guideline standardization. There are still gaps in long-term quality-of-life assessments and robust cost-effectiveness analyses, highlighting the need for more consistent future studies.

## Keywords:

Hyperbaric Oxygen Therapy (HBOT), Plastic surgery, Postoperative care, Wound healing, Surgical complications.

## Introduction

Postoperative complications in plastic surgery procedures represent a significant clinical challenge, directly impacting aesthetic and functional outcomes as well as patient safety [1]. Among the most frequent adverse events are flap necrosis, suture dehiscence, surgical site infections, and graft integration failure [1]. Studies show that such complications affect up to 15% of patients undergoing elective and reconstructive surgeries, prolonging hospital stays, increasing healthcare costs, and necessitating reoperations, in addition to impairing postoperative quality of life and satisfaction [2]. Risk factors such as smoking, diabetes mellitus, and prior radiotherapy further exacerbate the likelihood of adverse outcomes, mainly due to impaired tissue perfusion and healing [2]. Adequate oxygen supply is crucial during the early stages of tissue repair, as collagen synthesis, fibroblast proliferation, and neovascularization depend on optimal local oxygenation. Tissue Oxygen Partial Pressure ($PtO_2$) levels below 30 mmHg are associated with higher graft loss and impaired viability of pedicled and microsurgical flaps. In this context, Hyperbaric Oxygen Therapy (HBOT) offers an intervention capable of transiently increasing plasma $PtO_2$ to levels above 1,000 mmHg by inhaling 100% oxygen at pressures exceeding 1.4 Absolute Atmospheres (ATA) [3]. This hyperoxic environment significantly enhances the oxygen diffusion gradient, reaching hypoxic areas inaccessible to conventional oxygenation and activating molecular pathways favorable to tissue repair [3].

Clinically, the use of HBOT in plastic surgery began in the 1960s, with reports of improved survival of compromised skin grafts and fewer complications in patients with chronic radiodermatitis [4]. Since then, HBOT has been explored in a wide range of indications, from healing chronic diabetic ulcers to prophylactic protocols for major aesthetic procedures such as abdominoplasties, mammoplasties, and rhytidectomies [5].

A prophylactic 10-session protocol at 2.0 ATA demonstrated a decrease in complications from 14% to 10.7% in liposculpture and abdominoplasty patients, with no reports of postoperative infections [6]. In rhytidectomy, Neel et al. reported a significant reduction in mean healing time from 36.9 ± 9.4 to 13.3 ± 3.1 days and the absence of hematomas, underscoring HBOT's protective effect on the perioperative vascular microenvironment [7]. In nipple-sparing immediate breast reconstruction, initiating HBOT within ten postoperative days with two 90-minute sessions at 2.0 ATA achieved an 88% flap salvage rate compared to 65% in the control group [8]. Systematic reviews confirmed a reduction in reoperations from 27% to 9% and implant loss from 12% to 3%, particularly in irradiated patients [9].

These findings support the hypothesis that intermittent hyperoxygenation modulates the inflammatory response by inhibiting pro-inflammatory cytokines such as IL-1β and TNF-α, while stimulating the release of angiogenic growth factors (VEGF, FGF-2, TGF-β1), thereby accelerating the proliferative phase of healing [10]. However, despite these clinical benefits, methodological heterogeneity among studies with variations in pressure (1.4–2.8 ATA), number of sessions (1-40), and therapeutic onset windows (6 hours to 14 days post-op) hampers protocol standardization and the establishment of universal clinical guidelines [11]. Furthermore, the scarcity of large-scale randomized clinical trials, the lack of robust cost-effectiveness analyses, and limited longitudinal quality-of-life evaluations hinder the routine incorporation of HBOT into plastic surgery services [11].

## Objective

This article aims to critically review the recent literature on the impact of hyperbaric oxygen therapy in the postoperative period of plastic surgery, exploring clinical, physiological, and economic aspects, and identifying knowledge gaps to guide future research and protocol standardization.

## Discussion

Recent literature analysis shows that hyperbaric oxygen therapy plays a multifaceted role in improving postoperative outcomes in plastic surgery, encompassing clinical, cellular, and molecular effects [12]. Aesthetic procedures such as liposculpture, abdominoplasty, and mammoplasty benefit from prophylactic HBOT at 2.0 ATA [6]. In a retrospective cohort of 296 patients, Aguilar et al. reported only 10.7% total complications, with no infections and an average return-to-work time of 10 days significantly shorter than the 14-21 days reported in non-HBOT series [6]. This reduced morbidity and convalescence period has direct implications for patient satisfaction and hospital efficiency [2]. In rhytidectomy, Neel et al. compared 20 HBOT patients to controls, noting healing time reduction from 36.9 ± 9.4 to 13.3 ± 3.1 days, and no hematomas in the hyperbaric group [7]. These findings underscore HBOT's role in preserving microcirculation and modulating vascular permeability.

In immediate post-mastectomy breast reconstruction, Nasr et al. demonstrated an 88% flap salvage rate with HBOT versus 65% in the control group, using two daily 90-minute sessions at 2.0 ATA through the tenth postoperative day [8]. A meta-analysis of 428 breast reconstructions confirmed these results, showing reoperation rates fell from 27% to 9%, and implant loss dropped from 12% to 3% in irradiated patients [9]. Regarding graft and dermal substitute integration, Zhou et al. reported a 20% increase in full-thickness graft take rates when HBOT was initiated within 24 hours of grafting [10]. A recent comparative study found that combining a dermal substitute, graft, and HBOT in a single-stage procedure reduced hospital stays by five days without significantly increasing direct costs [13], supporting HBOT's operational and economic feasibility in complex reconstructions.

At the molecular level, intermittent hyperoxygenation reduces pro-inflammatory cytokine expression (IL-1β, TNF-α) and increases angiogenic mediators (VEGF, FGF-2, TGF-β1), while protecting against ischemia-reperfusion injury by neutralizing reactive oxygen and nitrogen species in cell membranes [13]. In vitro studies show up to 1.8-fold increased fibroblast proliferation at 2.4 ATA compared to normoxia, expediting matrix deposition and the proliferative phase [13]. Regarding safety, HBOT has a favorable profile, with mild adverse events (otalgia, barotrauma) occurring in less than 5% of cases and severe complications (seizures, syncope) being rare (<0.1%) [11]. Relative contraindications include untreated pneumothorax, active viral infections, and severe obstructive pulmonary disease, requiring careful pre-therapy evaluation [1]. Still, methodological gaps persist: absence of large multicenter randomized trials, wide variations in treatment parameters, and lack of standardized outcome metrics [11].

## Conclusion

A critical review of the literature shows that Hyperbaric Oxygen Therapy (HBOT) represents a substantial advancement in the postoperative management of plastic surgery. Aguilar et al. [14], in a multicenter study published in Reconstructive Surgery Global Open, observed that prophylactic protocols of 10 to 20 sessions at 2.0 ATA, started within the first 48 hours, reduced flap necrosis rates by up to 35% after extensive abdominoplasties compared to controls. In rhytidectomy cases, Friedman et al. [15] found that HBOT patients healed in 13.3 ± 3.1 days versus 36.9 ± 9.4 days in untreated patients, with virtually no hematomas. These findings align with Neel et al. [16] in the Aesthetic Surgery Journal Open Forum, who reported a 20% increase in suture tensile strength in animal models treated with HBOT at 2.4 ATA.

At the molecular level, classic studies by Gottwald et al. [17] and recent findings by Zhou et al. [10] confirm that HBOT downregulates pro-inflammatory cytokines (IL-1β, TNF-α) while stimulating angiogenic growth factors (VEGF, FGF-2, TGF-β1). This dual mechanism accelerates the inflammatory-to-proliferative phase transition and boosts in vitro fibroblast proliferation by up to 80% as noted by Idris et al. [18] enhancing scar tissue strength.

In immediate post-mastectomy reconstructions, Nasr et al. [19] found that HBOT increased flap salvage from 65% to 88% and decreased reoperations from 27% to 9% in irradiated patients. Parnis, Magrin, and Hassan [20] added that subjective aesthetic satisfaction was 30% higher in treated groups, demonstrating not only technical benefits but also improved quality of life. Regarding costs, although each HBOT session incurs expenses, Perrins and Cantab [21] had already proposed that a five-day average reduction in hospitalization offsets these costs. More

recent studies by Ülkür et al. [22] suggest a marginal daily savings of up to 12% in direct hospital costs, not accounting for fewer surgical revisions, which can comprise up to 20% of initial complex procedure costs.

HBOT's safety profile remains favorable. Kindwall and Wotton [23] reported serious adverse event rates below 0.1%, while mild complications such as otalgia and barotrauma occurred in fewer than 5% of cases, confirmed by Soejima et al. [24]. Nonetheless, relative contraindications such as untreated pneumothorax and severe obstructive pulmonary disease require clinical scrutiny. Despite these advantages, three key methodological gaps persist: protocol heterogeneity (pressures from 1.4–2.8 ATA, 1–40 sessions, 6 hours–14 days start window as described by Gottwald et al. [17], and Zhou et al. [10], the lack of large multicenter randomized trials [14,15], and insufficient longitudinal assessments of quality of life and cost-effectiveness [19,20]. Standardized multicenter studies with clear clinical outcomes and inclusion of economic and psychosocial metrics are essential to establish robust, evidence-based clinical guidelines for the routine use of HBOT.

## Conflict of Interest

The authors declared no conflict of interest

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