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SKIN NECROSIS FOLLOWING AESTHETIC PROCEDURES: MECHANISMS, PREVENTION, AND MANAGEMENT STRATEGIES

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ABSTRACT

The growing global demand for minimally invasive aesthetic procedures has reshaped contemporary dermatologic and aesthetic practice. Although generally considered safe, these treatments carry a small but potentially severe risk of vascular complications. Among them, skin necrosis represents one of the most serious adverse outcomes, potentially leading to permanent scarring, tissue loss, functional impairment, and psychological distress. While dermal filler injections are most frequently implicated, ischemic injury has also been reported following autologous fat grafting, thread lifting, energy-based procedures, and deep chemical peels.

This narrative review provides a clinical overview of the pathophysiology, risk factors, clinical presentation, prevention, and management of skin necrosis associated with aesthetic procedures. A literature search was conducted in PubMed, Scopus, and Web of Science for English-language publications between January 2015 and January 2025, focusing on vascular compromise and ischemic complications in aesthetic medicine.

Current evidence indicates that intravascular injection and external vascular compression are the primary mechanisms leading to tissue ischemia.

Early recognition of warning signs—including sudden blanching, severe pain, and livedoid discoloration—is essential, as delayed intervention increases the risk of irreversible damage. Management depends on the causative procedure, with hyaluronidase playing a central role in hyaluronic acid–related complications. Prevention relies on anatomical expertise, cautious injection techniques, and structured clinical preparedness, while standardized treatment algorithms and improved complication reporting remain essential for enhancing patient safety in modern aesthetic practice.

KEYWORDS

Skin Necrosis, Vascular Occlusion, Dermal Filler, Facial Anatomy, Hyaluronidase, Ischemic Complications

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I. Introduction

Over the past decade, minimally invasive aesthetic procedures have expanded rapidly worldwide. Treatments such as hyaluronic acid fillers, autologous fat grafting, thread lifting, and various energy-based devices are widely used for facial rejuvenation and contouring. Although these procedures are generally considered safe when performed by trained practitioners, serious complications may occur, including vascular occlusion and subsequent skin necrosis (Beleznay et al., 2015b; De Boulle & Heydenrych, 2015).

Skin necrosis represents one of the most severe ischemic complications encountered in aesthetic medicine. It results from acute interruption of arterial blood flow, which leads to tissue hypoxia and cellular damage when perfusion is not rapidly restored. Although the overall incidence is relatively low, the consequences can be significant and may include permanent scarring, tissue loss, functional impairment, and psychological distress (Goodman & Clague, 2016; Kapoor & Kapoor, 2016).

Most reported cases are associated with dermal filler injections, particularly those involving hyaluronic acid, where intravascular injection or external vascular compression may compromise arterial circulation (Signorini et al., 2016; DeLorenzi, 2017). However, ischemic injury has also been documented following autologous fat grafting, thread lifting, and energy-based procedures such as high-intensity focused ultrasound (HIFU) (Yang et al., 2020; Li et al., 2018; Alghoul & Codner, 2018).

The underlying pathophysiology is typically related to arterial obstruction caused either by embolization of injected material or by external compression of blood vessels. In certain situations, retrograde filler flow may extend toward the ophthalmic circulation, potentially leading to severe complications such as retinal artery occlusion and vision loss (Park et al., 2015; Lazzeri et al., 2016). Early recognition of ischemic warning signs—including sudden blanching, severe pain, and livedoid discoloration—is therefore critical to prevent irreversible tissue injury (Snozzi & van Loghem, 2018; Heydenrych et al., 2018).

Despite increasing awareness of vascular complications, management strategies in clinical practice remain heterogeneous. Although several expert consensus recommendations and treatment protocols have been proposed, a universally standardized management algorithm has not yet been established (Signorini et al., 2016; Beleznay & Carruthers, 2017).

Recent technological developments may also contribute to improving procedural safety in aesthetic medicine. High-frequency ultrasound imaging is increasingly used for vascular mapping and for the assessment of filler placement, allowing clinicians to visualize anatomical structures and potentially reduce the risk of intravascular injection (Wortsman, 2016; Schelke et al., 2020). In addition, advanced imaging techniques may assist in the early identification and management of vascular complications following aesthetic procedures (Schelke et al., 2018; Schelke et al., 2020).

The aim of this narrative review is to synthesize current evidence regarding the mechanisms, risk factors, clinical presentation, prevention strategies, and management of skin necrosis following aesthetic procedures, with particular emphasis on vascular complications associated with injectable treatments.

II. Methodology

This study was conducted as a narrative review aimed at synthesizing current clinical evidence on skin necrosis associated with aesthetic procedures. The objective was to provide a structured overview of epidemiology, pathophysiology, clinical presentation, prevention strategies, and management approaches rather than to perform a formal systematic review or meta-analysis.

A literature search was conducted in PubMed/MEDLINE, Scopus, and Web of Science, covering publications from January 2015 to January 2025. The search strategy used combinations of the following

keywords connected with Boolean operators (AND/OR): “skin necrosis,” “vascular occlusion,” “dermal filler complications,” “aesthetic procedures,” “hyaluronidase,” “fat grafting complications,” “thread lifting complications,” “laser-induced skin necrosis,” and “ischemic complications in aesthetic medicine.” Particular emphasis was placed on recent publications, consensus guidelines, and clinical studies addressing vascular complications in aesthetic practice.

Titles and abstracts were initially screened for relevance, followed by full-text evaluation of potentially eligible publications. When addressing overlapping research questions, priority was given to higher levels of clinical evidence, including systematic reviews, consensus statements, comparative clinical studies, and larger cohort studies.

Inclusion criteria comprised English-language publications involving human participants, including randomized controlled trials, cohort studies, case–control studies, systematic reviews, meta-analyses, consensus statements, and clinical guidelines related to ischemic complications following aesthetic procedures.

Exclusion criteria included animal studies, in vitro investigations without clinical correlation, isolated case reports lacking sufficient clinical detail, conference abstracts, and publications not directly related to aesthetic medicine or vascular complications.

Due to the heterogeneity in study design, patient populations, aesthetic procedures, injected materials, and reported outcome measures, the findings were synthesized qualitatively rather than through quantitative meta-analytic pooling.

As this review relied exclusively on previously published data, ethical approval was not required.

III. Results

1. Epidemiology and Risk Factors

Accurate epidemiological data on skin necrosis following aesthetic procedures remain limited, primarily due to underreporting and the absence of standardized complication registries (Goodman & Clague, 2016). Available clinical reports suggest that vascular occlusion following dermal filler injections is relatively rare, with estimated incidences ranging from approximately 0.001% to 0.01%, although the true frequency may be underestimated due to reporting bias (Beleznay et al., 2015b; DeLorenzi, 2017).

Most reported ischemic events are linked to hyaluronic acid filler injections, reflecting their widespread application and the potential for intravascular embolization (Signorini et al., 2016). However, vascular compromise has also been observed following procedures such as autologous fat grafting, thread lifting, and energy-based treatments like high-intensity focused ultrasound (HIFU), indicating that ischemic injuries are not confined to injectable fillers (Yang et al., 2020; Li et al., 2018; Alghoul & Codner, 2018).

Risk factors can be classified into three main categories: anatomical, procedural, and patient-related.

Anatomical risk factors are closely associated with areas supplied by terminal arterial branches that have limited collateral circulation. High-risk regions include the glabella, nasal dorsum, nasolabial fold, and forehead (Cotofana et al., 2019; Pavicic et al., 2020). The presence of direct anastomoses with the ophthalmic artery heightens the risk of both cutaneous necrosis and ocular complications.

Procedural risk factors encompass high injection pressure, large bolus volumes, incorrect injection planes, and insufficient understanding of vascular anatomy (Kapoor & Kapoor, 2016; Sykes & Cotofana, 2021). Although blunt cannulas are often considered safer than sharp needles, cases of vascular occlusion have been reported with both instruments, indicating that injection technique may be more important than the device itself (Pavicic et al., 2020). The practice of aspiration before injection remains contentious due to its inconsistent reliability and documented instances of false-negative results (Torbeck et al., 2019; van Loghem et al., 2018).

Patient-related risk factors may include previous surgical interventions, the presence of scar tissue, smoking habits, vascular diseases, and anatomical variations (De Boulle & Heydenrych, 2015). In the context of autologous fat grafting, larger particle sizes and greater injection volumes have been linked to an increased risk of embolism (Yang et al., 2020).

The expanding availability of aesthetic procedures across diverse clinical settings may also influence complication rates, particularly when practitioner training and emergency preparedness vary between providers (Signorini et al., 2016). These findings reflect variability in safety practices and reporting standards across clinical settings.

2. Pathophysiology

Skin necrosis following aesthetic procedures most commonly results from acute interruption of arterial blood flow, leading to tissue ischemia and subsequent cellular injury. Two principal mechanisms are typically involved: intravascular embolization and extrinsic vascular compression (DeLorenzi, 2017; Signorini et al., 2016).

2.1 Intravascular Embolization

Inadvertent intravascular injection occurs when filler material is deposited directly into the lumen of an artery. If the injection pressure surpasses the arterial systolic pressure, retrograde flow may occur, allowing the filler to travel proximally before moving anterogradely into distal arterial branches (DeLorenzi, 2017). This mechanism accounts for both localized cutaneous ischemia and severe complications, such as retinal artery occlusion (Park et al., 2015; Lazzeri et al., 2016).

Hyaluronic acid fillers may obstruct arterial vessels by forming cohesive embolic material within the vascular lumen. The degree of ischemia is influenced by vessel caliber, collateral circulation, and the time taken for reperfusion (Beleznay et al., 2015b).

In cases of autologous fat embolism, more extensive vascular obstruction can occur because aggregates of adipocytes can occlude larger-caliber vessels and are resistant to enzymatic degradation (Yang et al., 2020). As a result, ischemia following fat grafting may be more severe and less responsive to treatment.

2.2 Extrinsic Vascular Compression

Extrinsic compression arises when filler material applies external pressure on nearby vessels, particularly in confined anatomical areas like the nasal dorsum or glabellar region (Goodman & Clague, 2016). Progressive edema or inflammatory swelling can further compromise vascular integrity.

This mechanism may also be relevant in thread-lifting procedures, where mechanical tension or improperly positioned threads can compress vascular structures (Alghoul & Codner, 2018).

2.3 Ischemic Cascade and Tissue Injury

Reduced arterial perfusion initiates a sequence of ischemic events involving endothelial injury, platelet aggregation, and microvascular thrombosis. Hypoxia leads to endothelial dysfunction, platelet aggregation, microvascular thrombosis, and the release of inflammatory mediators. Prolonged ischemia results in cellular necrosis, loss of epidermal integrity, and eventual eschar formation (Snozzi & van Loghem, 2018).

Both experimental and clinical observations indicate that irreversible tissue damage may occur within a few hours if perfusion is not restored (DeLorenzi, 2017). Thus, the speed of intervention is crucial in preventing full-thickness necrosis.

2.4 Material-Specific Considerations

The reversibility of ischemia varies depending on the type of material injected. Hyaluronic acid fillers provide a therapeutic advantage due to the availability of hyaluronidase, which can enzymatically degrade the filler and potentially restore blood flow (Beleznay & Carruthers, 2017). In contrast, non-hyaluronic acid fillers and fat grafts do not have a specific antidote, making prevention and prompt supportive management essential.

Thermal injuries from energy-based devices, such as high-intensity focused ultrasound (HIFU), represent a different pathophysiological pathway. In these cases, vascular damage occurs due to direct heat-induced endothelial injury rather than embolization (Li et al., 2018).

3. High-Risk Anatomical Areas

Certain facial regions carry a higher risk of vascular compromise due to their arterial anatomy and limited collateral circulation. Familiarity with these anatomical “danger zones” is essential for minimizing the risk of ischemic complications during aesthetic procedures (Cotofana et al., 2019; Pavicic et al., 2020).

3.1 Glabella

The glabellar region represents one of the highest-risk areas for vascular complications during filler injections. It is mainly supplied by the supratrochlear and supraorbital arteries, which are terminal branches of the ophthalmic artery. Given the limited collateral circulation in this area, vascular occlusion may rapidly lead to tissue necrosis or even retrograde embolization toward the central retinal artery (Beleznay et al., 2015a; Lazzeri et al., 2016). Injections in this region should be performed with caution, utilizing minimal volumes and superficial planes when appropriate.

3.2 Nasal Dorsum and Nasolabial Region

The nasal dorsum is particularly vulnerable because of its vascular connections with the angular artery and the ophthalmic circulation. Intravascular injection in this area has been strongly linked to both cutaneous necrosis and vision-threatening complications (Park et al., 2015; Signorini et al., 2016). The nasolabial fold also poses a risk because of the facial artery and its branches. Deep bolus injections in this region may compress or occlude the angular artery, especially when large volumes are utilized (Kapoor & Kapoor, 2016).

3.3 Forehead and Temporal Region

The forehead receives its vascular supply from branches of the ophthalmic artery. Due to the presence of vertical arterial pathways and the relatively superficial location of vessels, filler injections in this area require particular caution (Pavicic et al., 2020). The temporal region contains the superficial temporal artery and its branches. While necrosis is less frequently reported in this area compared to the glabella or nasal dorsum, inadvertent intravascular injection remains a possibility (Cotofana et al., 2019).

3.4 Periorbital Area

The periorbital region is characterized by complex vascular anatomy with multiple arterial anastomoses. Injections in the tear trough area must consider the infraorbital artery and its anastomoses. Misplacement in this area may lead to vascular compromise or retrograde embolization (Sykes & Cotofana, 2021).

3.5 Chin and Mandibular Region

Although generally considered safer than the midface, the chin and mandibular region contain branches of the facial and submental arteries. Vascular complications have been documented following chin augmentation procedures (Wang et al., 2018).

In summary, the highest-risk zones are those supplied by branches of the ophthalmic artery, due to the potential for both cutaneous necrosis and ocular complications. A detailed understanding of three-dimensional facial vascular anatomy and its variability is essential for reducing the risk of vascular complications (Cotofana et al., 2019; Pavicic et al., 2020).

A summary of the highest-risk anatomical regions and their associated vascular risks is presented in Table 1.

Table 1. High-Risk Anatomical Areas for Vascular Complications in Aesthetic Medicine

Anatomical Area	Main Arterial Supply	Major Risk	Key References
Glabella	Supratrochlear and supraorbital arteries (branches of the ophthalmic artery)	Cutaneous necrosis and retinal artery occlusion	Beleznay et al., 2015b; Lazzeri et al., 2016
Nasal dorsum	Angular artery; dorsal nasal artery (anastomosis with ophthalmic artery)	Cutaneous necrosis and vision-threatening embolization	Park et al., 2015; Signorini et al., 2016
Nasolabial fold	Facial artery branches (including angular artery)	Cutaneous ischemia and vascular compression	Kapoor & Kapoor, 2016
Forehead	Branches of the ophthalmic artery	Local ischemia or intravascular injection	Pavicic et al., 2020
Temporal region	Superficial temporal artery	Local ischemia or vascular compromise	Cotofana et al., 2019
Periorbital (Tear trough)	Infraorbital artery; ophthalmic anastomoses	Vascular compromise and ocular embolization	Sykes & Cotofana, 2021
Chin / Mandibular region	Facial artery branches; submental artery	Local ischemia	Wang et al., 2018

4. Clinical Presentation and Early Recognition of Ischemic Complications

Early recognition of vascular compromise plays a key role in determining tissue survival. The clinical signs of impending skin necrosis typically occur during injection or within minutes thereafter, although cases of delayed-onset ischemia have also been reported (Snozzi & van Loghem, 2018; Heydenrych et al., 2018).

4.1 Immediate Signs During Injection

One of the earliest clinical signs is sudden blanching of the skin within the vascular territory supplied by the affected artery. This blanching is often sharply defined and may follow a linear or angiosome-like pattern corresponding to the underlying vascular anatomy (Signorini et al., 2016; Beleznay et al., 2015b).

Severe and disproportionate pain occurring during or immediately after the injection is another key indicator of arterial occlusion (Kapoor & Kapoor, 2016; DeLorenzi, 2017). Unlike the mild discomfort typically associated with filler placement, ischemic pain is persistent, intense, and may radiate beyond the injection site. Patients often report a burning or throbbing sensation, reflecting acute vascular insufficiency and endothelial irritation (Goodman & Clague, 2016).

4.2 Early Post-Injection Changes

Within minutes to hours, the affected area may exhibit a livedoid or reticular discoloration, indicating compromised microvascular perfusion (Snozzi & van Loghem, 2018). This mottled appearance often precedes more obvious signs of necrosis. As ischemia progresses, the skin may take on a dusky, violaceous, or cyanotic hue. Capillary refill may be delayed or absent, and while edema may be present, it should not be mistaken for normal post-injection swelling (Heydenrych et al., 2018).

If reperfusion does not occur, epidermolysis, blistering, and superficial ulceration may develop within 24 to 72 hours (Signorini et al., 2016; DeLorenzi, 2017). Untreated, this can lead to full-thickness necrosis, resulting in eschar formation and permanent scarring.

4.3 Ocular and Neurological Symptoms

In high-risk areas supplied by branches of the ophthalmic artery, vascular occlusion may extend beyond cutaneous territories. Retrograde embolization of filler material has been linked to retinal artery occlusion and sudden vision loss (Park et al., 2015; Lazzeri et al., 2016).

Patients may report:

- Sudden visual impairment or blindness
- Ptosis
- Ophthalmoplegia
- Severe headache

Although rare, these complications are severe and require immediate ophthalmologic evaluation (Beleznay et al., 2015a; Beleznay et al., 2019).

4.4 Clinical Differences Between HA Fillers and Fat Grafting

The clinical course of vascular compromise may vary depending on the injected material. Vascular compromise related to hyaluronic acid often presents quickly but allows for enzymatic reversal with hyaluronidase (Beleznay & Carruthers, 2017; DeLorenzi, 2017). In contrast, ischemia following autologous fat grafting may be more extensive due to larger particle sizes and proximal embolization (Yang et al., 2020). Fat embolism has been associated with more severe and widespread ischemic patterns compared to HA fillers.

4.5 Delayed-Onset and Atypical Presentations

Although most cases arise immediately, delayed ischemic events have been documented. Delayed ischemic events may result from progressive vascular compression, secondary thrombosis, or inflammatory edema (De Boulle & Heydenrych, 2015). Thread-lifting procedures may lead to localized ischemia through mechanical compression of vascular structures rather than intravascular embolization (Alghoul & Codner, 2018). Similarly, thermal injury from high-intensity focused ultrasound (HIFU) can cause vascular damage and subsequent tissue necrosis (Li et al., 2018).

Delayed-onset nodules and inflammatory reactions should be distinguished from true ischemia, as their management strategies differ significantly (Beleznay et al., 2015b).

4.6 Role of Imaging in Clinical Assessment

High-frequency ultrasound has emerged as an important imaging modality in the evaluation of suspected vascular compromise. Sonography can detect intravascular filler deposits, visualize vascular flow patterns, and assist in guiding targeted hyaluronidase administration (Wortsman, 2016; Schelke et al., 2020). Additionally, ultrasound can help differentiate between vascular occlusion and other complications such as edema, hematoma, or delayed inflammatory reactions (Schelke et al., 2018). The integration of imaging into aesthetic practice enhances diagnostic accuracy and facilitates more precise management.

4.7 Clinical Red Flags Requiring Immediate Intervention

Based on consensus recommendations and published case analyses, the following features should prompt the immediate initiation of treatment:

- Sudden blanching during injection
- Severe disproportionate pain
- Livedoid discoloration
- Delayed capillary refill
- Visual symptoms
- Rapid progression of dusky skin changes

(Signorini et al., 2016; Heydenrych et al., 2018; DeLorenzi, 2017)

Delays in intervention are strongly associated with poorer outcomes and a higher likelihood of permanent scarring (Beleznay et al., 2015b; Goodman & Clague, 2016).

5. Immediate Management

Prompt and structured intervention plays a critical role in preserving tissue viability following vascular compromise. While there is no universally standardized protocol, various consensus statements and expert recommendations provide a framework for evidence-based management (Signorini et al., 2016; Heydenrych et al., 2018). The management strategy depends on the injected material, the anatomical location, and the severity of ischemia.

5.1 Immediate Action at First Suspicion of Vascular Occlusion

When vascular compromise is suspected, treatment should commence immediately, even before full clinical confirmation (DeLorenzi, 2017). The following steps are widely recommended:

1. Stop the injection immediately.
2. Assess capillary refill and the severity of pain.
3. Vigorously massage the affected area to disperse the filler material.
4. Apply warm compresses to promote vasodilation.
5. Evaluate for any visual symptoms.

Time is a critical factor, as delays of several hours significantly increase the risk of irreversible tissue necrosis (Beleznay et al., 2015b).

5.2 High-Dose Pulsed Hyaluronidase Protocol (HA Fillers)

For cases involving hyaluronic acid fillers, hyaluronidase is the cornerstone of treatment (Beleznay & Carruthers, 2017; DeLorenzi, 2017).

DeLorenzi proposed a high-dose pulsed protocol, which includes:

- Immediate injection of high-dose hyaluronidase (typically 450–1500 units or more, depending on the area and severity)
- Reassessment after 30–60 minutes
- Repeated administration may be required until clinical signs of reperfusion are observed

The objective is to achieve rapid enzymatic degradation of intravascular or extravascular hyaluronic acid (DeLorenzi, 2017). Consensus recommendations stress the importance of injecting hyaluronidase not only into the area of necrosis but also along the course of the affected artery (Signorini et al., 2016). Evidence indicates that early and aggressive administration of hyaluronidase significantly improves outcomes (Beleznay et al., 2015b).

5.3 Adjunctive Therapies

Although much of the evidence is based on expert opinion and case reports, several adjunctive therapies have been proposed in the management of vascular complications:

- Acetylsalicylic acid (aspirin) to reduce platelet aggregation (Kapoor & Kapoor, 2016).
- Low molecular weight heparin, although its use remains controversial and is not universally recommended (Kapoor & Kapoor, 2016; Heydenrych et al., 2018).
- Topical nitroglycerin paste to induce vasodilation, despite limited clinical evidence and potential side effects (Kapoor & Kapoor, 2016).
- Oral corticosteroids in selected cases to reduce secondary inflammatory edema (Heydenrych et al., 2018).

Hyperbaric oxygen therapy has also been proposed as an adjunctive treatment in selected cases to improve tissue oxygenation, although the available evidence remains limited and largely anecdotal (Loh et al., 2018; Hwang, 2016).

5.4 Management of Ocular Complications

If visual symptoms arise, an immediate referral to an ophthalmologist is essential. Interventions may include:

- Ocular massage
- Reduction of intraocular pressure
- Retrobulbar hyaluronidase (in specialized centers)

However, the visual prognosis remains poor in many reported cases despite intervention (Park et al., 2015; Lazzeri et al., 2016; Beleznay et al., 2019).

Prevention is far more effective than treatment in cases of ocular events.

5.5 Non–Hyaluronic Acid Fillers and Fat Grafting

For non-hyaluronic acid fillers and autologous fat grafting, no enzymatic reversal agent is currently available. Management is therefore primarily supportive and focuses on maintaining or restoring residual tissue perfusion (Yang et al., 2020).

Recommended supportive strategies include:

- Immediate massage
- Warm compresses
- Antiplatelet therapy
- Close monitoring
- Early referral to specialized centers

Autologous fat embolism may result in more extensive vascular obstruction due to larger particle sizes and potential involvement of proximal vessels (Yang et al., 2020).

5.6 Role of Ultrasound-Guided Management

High-frequency ultrasound has increasingly been integrated into management protocols for complications (Wortsman, 2016; Schelke et al., 2020).

Ultrasound allows for:

- Visualization of filler deposits
- Identification of arterial flow
- Targeted injection of hyaluronidase
- Assessment of reperfusion

The use of imaging enhances precision and may reduce unnecessary tissue trauma (Schelke et al., 2018).

As aesthetic medicine evolves, ultrasound-assisted management may become a standard practice.

5.7 Proposed Stepwise Clinical Algorithm

Based on current consensus recommendations and available literature, a structured stepwise approach to the management of suspected vascular occlusion can be outlined as follows:

Step 1: Immediate cessation of injection.
Step 2: Clinical assessment (pain, blanching, capillary refill).
Step 3: Massage and warm compress.
Step 4: Immediate high-dose hyaluronidase (if HA).
Step 5: Adjunctive pharmacologic therapy.
Step 6: Reassessment every 30–60 minutes.
Step 7: Referral if visual symptoms or progression occur.
Step 8: Close follow-up for at least 7–14 days.
(Signorini et al., 2016; DeLorenzi, 2017; Heydenrych et al., 2018).
The proposed stepwise management strategy is summarized in Table 2.

Table 2. Evidence-Based Stepwise Management of Suspected Vascular Occlusion Following Aesthetic Procedures

Step	Clinical Situation	Recommended Action	Key References
1	Sudden blanching and/or severe pain during injection	Immediately stop injection	Signorini et al., 2016; DeLorenzi, 2017
2	Suspected vascular compromise	Assess capillary refill, pain severity, and skin color	Heydenrych et al., 2018
3	Early ischemic signs (blanching, livedo)	Vigorous massage of affected area; apply warm compresses	Signorini et al., 2016; Kapoor & Kapoor, 2016
4	Confirmed or strongly suspected HA-related occlusion	High-dose pulsed hyaluronidase injection (450–1500+ IU), repeated every 30–60 minutes until reperfusion.	DeLorenzi, 2017; Beleznay & Carruthers, 2017; Beleznay et al., 2015b
5	Adjunctive therapy	Consider acetylsalicylic acid; optional topical nitroglycerin (limited evidence); consider corticosteroids in selected cases	Kapoor & Kapoor, 2016; Heydenrych et al., 2018; Snozzi & van Loghem, 2018
6	Ocular symptoms (vision changes, ptosis, ophthalmoplegia)	Immediate ophthalmologic referral and emergency management (ocular massage, intraocular pressure reduction; retrobulbar hyaluronidase in specialized centers).	Park et al., 2015; Lazzeri et al., 2016; Beleznay et al., 2019
7	Non-HA fillers or autologous fat grafting	Supportive management; no enzymatic reversal available; close monitoring and early referral	Yang et al., 2020; Loh et al., 2018
8	Persistent ischemia	Consider hyperbaric oxygen therapy in selected cases (limited evidence)	Loh et al., 2018; Hwang, 2016
9	Post-acute phase	Wound care, infection prevention, scar modulation (laser therapy, microneedling, PRP, silicone therapy)	Goodman & Clague, 2016

5.8 Long-Term Management and Sequelae

If tissue necrosis develops despite early intervention, subsequent management focuses on wound healing and the prevention of long-term sequelae.

- Wound care
- Infection prevention
- Debridement if necessary
- Scar modulation using techniques such as laser therapy, microneedling, platelet-rich plasma (PRP), or silicone therapy

(Goodman & Clague, 2016).

The psychological impact of facial necrosis should also be considered, particularly in patients undergoing aesthetic procedures.

6. Prevention Strategies

Reducing the risk of vascular complications in aesthetic practice requires a proactive and structured preventive approach. Because vascular occlusion may lead to irreversible tissue damage, prevention strategies should emphasize anatomical knowledge, safe injection techniques, careful patient selection, and preparedness for emergency management (Signorini et al., 2016; Heydenrych et al., 2018).

6.1 Anatomical Knowledge and Risk Mapping

A detailed understanding of three-dimensional facial vascular anatomy is essential for reducing the risk of vascular complications. High-risk "danger zones," including the glabella, nasal dorsum, nasolabial fold, and forehead, are supplied by branches of the ophthalmic and facial arteries, which have limited collateral circulation (Cotofana et al., 2019; Pavicic et al., 2020).

Anatomical variability further heightens procedural risk. Individual differences in vessel depth, branching patterns, and anastomoses can predispose patients to unexpected vascular compromise (Sykes & Cotofana, 2021). Therefore, while standardized injection landmarks are important, they should be supplemented with individualized anatomical assessments.

Increasingly, practitioners are utilizing pre-procedural vascular mapping with high-frequency ultrasound in high-risk cases. This imaging technique helps identify vessel location and depth, potentially reducing the risk of inadvertent intravascular injection (Wortsman, 2016; Schelke et al., 2020).

6.2 Injection Technique and Procedural Modifications

Appropriate injection technique is a key factor in preventing vascular complications during aesthetic procedures.

- Slow injection with minimal pressure
- Using small aliquots instead of large bolus injections
- Continuous needle movement (retrograde linear threading)
- Avoiding high-risk planes in danger zones
- Considering blunt cannulas in select areas

These recommendations are supported by consensus guidelines (Signorini et al., 2016; Kapoor & Kapoor, 2016).

While blunt cannulas may lower the risk of arterial penetration compared to sharp needles, they do not eliminate the risk entirely (Pavicic et al., 2020). Reports of vascular occlusion even with cannula use highlight the importance of technique and anatomical awareness.

Aspiration before injection has been suggested as a preventive measure; however, various studies have shown inconsistent sensitivity and the potential for false-negative results (Torbeck et al., 2019; van Loghem et al., 2018). Therefore, aspiration should not be relied upon as a standalone safety measure.

6.3 Product Selection and Volume Control

Excessive injection volumes and high-pressure delivery can increase the likelihood of vascular compression or embolization (DeLorenzi, 2017). Practitioners should avoid large bolus injections in high-risk areas and instead adopt a more incremental approach.

In fat grafting procedures, larger particle sizes and high-pressure injections are associated with a greater risk of embolism (Yang et al., 2020). Consequently, careful selection of cannulas and the use of low-pressure techniques are recommended.

For energy-based procedures such as HIFU, strict adherence to depth and energy settings is necessary to prevent unintended vascular injury (Li et al., 2018).

6.4 Patient Selection and Pre-Procedural Assessment

A thorough medical history should identify potential risk factors, including:

- Previous facial surgery
- Scarring
- Smoking
- Vascular disorders
- Coagulation abnormalities

(De Boulle & Heydenrych, 2015)

While there are no definitive contraindications that guarantee vascular safety, recognizing high-risk profiles can support more cautious techniques and informed consent.

6.5 Preparedness and Emergency Protocols

Every clinical setting that performs injectable aesthetic procedures should have an accessible emergency kit containing sufficient quantities of hyaluronidase (Signorini et al., 2016; Beleznay & Carruthers, 2017). Practitioners must be trained to recognize ischemic signs early and execute structured management algorithms. Regular simulation training and adherence to consensus-based protocols can enhance response times and improve clinical outcomes (Heydenrych et al., 2018).

Additionally, documentation and complication reporting systems are crucial for fostering collective learning and enhancing safety standards (Goodman & Clague, 2016).

6.6 Education and Standardization

Professional training, ongoing medical education, and standardized certification pathways play a significant role in influencing complication rates. As aesthetic medicine expands into various practice settings, maintaining consistent training standards becomes increasingly important (Signorini et al., 2016).

Integrating ultrasound education and anatomical simulation models may represent future directions in complication prevention (Schelke et al., 2020).

Effective prevention of vascular complications relies on a combination of anatomical expertise, cautious injection techniques, appropriate product selection, and clinical preparedness. While it is impossible to eliminate all risks, following evidence-based preventive measures can significantly reduce the incidence and severity of vascular complications.

IV. Discussion

Skin necrosis following aesthetic procedures is an uncommon but potentially serious complication that may lead to significant functional and psychological consequences. Despite the increasing amount of literature and consensus guidelines available, variations in clinical practice continue to exist. This review emphasizes that most ischemic events are preventable, and successful outcomes largely depend on early detection and timely intervention (Signorini et al., 2016; DeLorenzi, 2017).

One of the most debated aspects of safety in aesthetic procedures is the effectiveness of aspiration before injection. Traditionally, this has been recommended as a precautionary measure; however, studies have shown inconsistent sensitivity and a notable risk of false-negative results (Torbeck et al., 2019; van Loghem et al., 2018). Aspiration may be unreliable due to small needle gauge, filler viscosity, vessel collapse, or negative pressure dynamics. Therefore, relying solely on aspiration may create a false sense of security. Current consensus increasingly values anatomical knowledge and controlled injection techniques over routine aspiration as the primary safety measure (Heydenrych et al., 2018).

Another contentious topic is the choice between cannulas and sharp needles. Cannulas are often considered safer due to their blunt tips, theoretically reducing the likelihood of arterial penetration. However, there have been reports of vascular occlusion occurring even when cannulas are used, indicating that no device is completely without risk (Pavicic et al., 2020). Regardless of the instrument used, proper plane selection, slow injection rates, and minimal pressure are essential.

The management of vascular occlusion related to hyaluronic acid has advanced significantly over the past decade. The high-dose pulsed hyaluronidase protocol introduced by DeLorenzi (2017) and supported by subsequent expert recommendations has become a cornerstone of treatment. Prompt and aggressive enzymatic breakdown of the filler greatly enhances tissue survival rates (Beleznay & Carruthers, 2017). Nevertheless, a universally accepted dosing regimen has not yet been established, and treatment decisions often rely on clinical judgment.

In contrast, ischemic complications arising from autologous fat grafting or non-HA fillers present greater challenges due to the lack of a specific reversal agent (Yang et al., 2020). Fat embolism, in particular, may result in proximal and extensive vascular obstruction, potentially leading to more severe clinical outcomes. These differences highlight the need for management protocols tailored to specific materials.

The use of ultrasound in aesthetic practice represents one of the most promising advancements for preventing and managing complications. High-frequency sonography enables visualization of filler placement, vascular flow, and targeted administration of hyaluronidase (Wortsman, 2016; Schelke et al., 2020). Although not yet widely adopted, ultrasound-guided procedures may become the standard of care, especially in high-risk anatomical areas.

Ocular complications, while rare, are among the most serious consequences of intravascular filler injection. Visual outcomes are often poor, even with immediate intervention (Park et al., 2015; Lazzeri et al., 2016). This reality underscores the importance of prevention, which is significantly more effective than treatment in cases involving the eyes. The anatomical connections between facial arteries and the ophthalmic circulation necessitate extreme caution in areas such as the glabella, nasal dorsum, and forehead (Cotofana et al., 2019).

Another important challenge is the underreporting of complications in aesthetic practice. The actual incidence of vascular complications may be underestimated due to inconsistent reporting systems and varying levels of practitioner training (Goodman & Clague, 2016).

Finally, the increasing availability of aesthetic procedures outside specialized dermatologic or surgical settings raises concerns about operator training and emergency preparedness. Ensuring access to hyaluronidase, structured management algorithms, and simulation-based education should be considered minimum safety requirements in clinical practice (Signorini et al., 2016; Heydenrych et al., 2018).

A significant limitation within the current literature is the lack of standardized management protocols and uniform reporting criteria. Although several expert consensus documents propose structured treatment algorithms, recommended dosing regimens for hyaluronidase, adjunctive pharmacologic measures, and follow-up strategies vary widely among publications (Signorini et al., 2016; DeLorenzi, 2017; Heydenrych et al., 2018). Moreover, much of the available evidence comes from retrospective analyses, case series, and expert opinions rather than prospective controlled studies, which limits the robustness of the recommendations (Beleznay et al., 2015b; Goodman & Clague, 2016). The absence of large-scale prospective datasets and standardized outcome definitions complicates accurate risk stratification and comparison of treatment methods. Establishing international complication registries with harmonized reporting standards could substantially improve epidemiological accuracy, enable protocol comparison, and support the development of unified evidence-based clinical guidelines (Goodman & Clague, 2016).

Overall, current evidence supports a multifactorial approach to risk reduction integrating anatomical expertise, controlled injection techniques, rapid intervention protocols, and technological advancements such as ultrasound guidance. Future research should prioritize prospective registry-based designs, standardized hyaluronidase dosing trials, and the integration of emerging technologies—including artificial intelligence–assisted vascular mapping—to further improve procedural safety, risk stratification, and outcome predictability.

V. Conclusions

Although uncommon, skin necrosis following aesthetic procedures can lead to significant functional impairment and psychological distress. The increasing demand for minimally invasive facial treatments underscores the need for standardized safety protocols.

Most cases are associated with vascular occlusion resulting from intravascular injection or external compression of blood vessels, particularly in high-risk anatomical regions. Early recognition of warning signs—such as sudden blanching, severe pain, and livedoid discoloration—is essential to prevent irreversible tissue injury.

Hyaluronidase remains the primary treatment for complications related to hyaluronic acid fillers, whereas ischemic events associated with autologous fat grafting or non-hyaluronic acid fillers present greater therapeutic challenges. Despite the availability of several consensus recommendations, a universally accepted management algorithm has not yet been established.

Future research should prioritize prospective data collection, standardized reporting systems, and the development of unified evidence-based management algorithms to further improve patient safety in aesthetic medicine.

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