Subcutaneous, orbital, and mediastinal emphysema secondary to the use of an air-abrasive device

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Abstract Subcutaneous emphysema can occur whenever compressed air is employed intraorally. A case is presented of subcutaneous, orbital, and mediastinal emphysema subsequent to the use of an air-abrasive device. The case is believed to be the first reported case of an air-abrasive-related emphysema and is presented as a cautionary report. (Quintessence Int 1997;28:31-38.)

Introduction

The term emphysema originates from the ancient Greek and means "to blow in." In spite of the extensive use of compressed air in the delivery of ambulatory nonsurgical dental procedures, the incidence of emphysematous complications in dentistry is remarkably low. A recent review of the literature suggests that many cases may, in fact, go unnoticed or unreported or simply misdiagnosed. Most reports in the literature reveal that dentists, primary care physicians, and emergency room physicians are unfamiliar with emphysematous complications.

The employment of extraordinarily high-pressurized microscopic abrasive powder in the newly reemerged air-abrasive technology has the potential to increase the morbidity of emphysematous complications. The objectives of this article are to highlight this iatrogenic potential and to draw the profession’s attention toward the need for vigilance during the use of air-abrasive devices.

Case report

A 16-year-old patient, in excellent health, presented for restorative treatment in the maxillary left posterior sextant. Radiographic examination revealed a cavitated occlusal lesion on the first molar. Minimal carious involvement was noted on the second molar, while the premolars displayed elaborate but caries-free fissures.

Restorative procedure

Subsequent to the administration of local anesthesia, a retainer was applied to the first molar, and the working field was isolated with dental dam through to the premolars. Although the second molar was to be included in the operative effort, incomplete eruption precluded its use as an anchor.

The first molar was restored with a resin composite restoration. An air-abrasive device was used to remove stains and organic debris from the remaining fissures of the first molar and the premolars in preparation for sealant application. The isolated teeth were sealed with an opaque fissure sealant. The dental dam was removed to facilitate restoration of the second molar.

An air-abrasive cavity preparation system, with the air pressure set at 120 psi and the powder flow rate at high, was chosen as the ideal conservative means of debriding the minimal carious lesion of the second...
molar in preparation for a preventive resin treatment option.

The 0.015-inch tip of the handpiece was inadvertently (without the protection of dental dam) applied to the area of the distolingual gingival sulcus. The patient moaned in discomfort as an immediate "ballooning" of the patient's left facial and periorbital area was noted. The procedure was immediately aborted.

Immediate clinical picture

The patient, in mild distress, reported moderate discomfort across the swollen and erythematous portion of her face (Fig 1). Physical examination revealed outright asymmetry of the face, complete left ptosis, and crepitus on palpation from the outer canthus of the left eye, inferiorly along the posterior border of the ramus, to the angle of the mandible. A diagnosis of subcutaneous facial and orbital emphysema secondary to the inappropriate application of compressed air to the gingival tissues was made (Fig 2). The patient was assured that recovery would be uneventful and that the swelling would be expected to subside within 7 days.

The patient did not remark on any chest pain or breathing-associated discomfort. The patient was advised to avoid maneuvers that could further increase intraoral pressure.

Nine-hour mediastinal emphysema

The patient was admitted to the emergency department of a general hospital shortly before midnight that same evening, complaining of chest pain overlying the cardiac area and shortness of breath. Aside from the dental episode, the medical history was noncontributory. Physical examination revealed that the patient was afebrile but that the subcutaneous emphysema had now tracked to the mediastinal tissues (Figs 3 and 4). Auscultation of the chest demonstrated inspiratory crepitus.

Radiographic examination confirmed the presence of mediastinal air (Figs 5 and 6). The patient was monitored for a few hours, reassured of recovery, and cautioned to return promptly if any fever or worsening of the symptoms developed.
Fig 3. Diagram of the path of the compressed air subsequent to its intraoral application. From the retropharyngeal space, the air tracks down the right and left carotid sheathes to surround the heart.

Fig 4. Drawing of a cross section through the level of the C2 vertebrae showing the putative course of the air from the maxillary left second molar beneath the mucosa, between the tonsil bed and the superior constrictor on the medial side and between the tonsil bed and the medial pterygoid on the lateral aspect, to the retropharyngeal space. The retropharyngeal space lies between the superior constrictor and the prevertebral fascia.

Fig 5 (left). Anteroposterior radiograph of the thorax taken 9 hours after the initial event. This projection reveals that the majority of the air in the mediastinum follows the course of the carotid sheathes on both the left and right sides (arrows labeled 1).

Fig 6 (right). Lateral view of the thorax taken at the same time as Fig 5. Air can be seen in the mediastinum surrounding the bronchi (arrows labeled 2) and between the sternum and the heart (arrows labeled 3). It is not possible to determine whether the air is within or outside the pericardial sac.
Fig 7 Appearance of the patient 5 days after the initial episode. Crepitus was barely palpable, vision was restored, and the swelling had diminished considerably.

Fig 8 Appearance of the patient at 7 days after the episode. Her vision was back to normal, and her recovery was complete. Note the dramatic change from this normal view to the emphysematous episode depicted in Fig 1. The severity of the episode can only be fully appreciated when it is realized that this change was virtually instantaneous.

Recovery

The patient continued to improve and recovered from the incident without any further setbacks. At 24 hours, the swelling had subsided by 50%. At 5 days, recovery was 90% complete (Fig 7). The patient reported slight residual soreness of the structures of the neck and thorax. At 7 days, the patient’s vision was back to normal, and her recovery was complete (Fig 8). To date, at 1-year recall, no further adverse sequelae have been noted.

Discussion

Diagnosis

A sudden facial swelling occurring during a dental procedure involving pressurized air is characteristic of an emphysematic reaction. Although the diagnosis of emphysema in this patient was straightforward, given the ballooning nature of the swelling on application of the air-abrasive device, an initial diagnosis of an allergic reaction to the injection of local anesthetic must always be considered when rapid onset of edema occurs at a site of drug administration. An anaphylactic reaction is a sudden, intense, allergic reaction, mediated by the immune system’s release of histamine and other factors from the circulatory mast cells. This possibility must be foremost in a clinician’s mind when rapid edema occurs.4

The pathognomonic finding of emphysema is the crackling sensation (crepitus) on palpation of the subcutaneous tissues. Crepitus is not always immediately evident, however, and may appear after a number of hours.4 Although the onset of swelling is usually immediate, it may be delayed and progression may occur over several hours.5 Mediastinal air emphysema is suggested when the patient complains of dyspnea and chest or back pain.

Physical examination will commonly reveal Hamman’s sign—a friction rub synchronous with the heartbeat, heard on cardiac auscultation and suggestive of air in the pericardium.6 Recommended diagnostic radiologic studies include plain radiographs of the chest and neck (anteroposterior and lateral views).7 The lateral chest radiograph is often more helpful than the anteroposterior view because pneumomediastinum is usually diagnosed by the demonstration of air in the mediastinum, seen as retrosternal radiolucency.8

Treatment

Treatment for subcutaneous emphysema and each of its sequelae should be in accordance with the severity of the problem. In mild cases, simple observation and reassurance of resolution is the only treatment necessary because the complication normally runs a benign course. Measures to prevent transient increases in
intraoral pressure, as occur with coughing, sneezing, and nose blowing, are taken; these measures include the use of cough suppressants and decongestants. Prophylactic antibiotic treatment, previously routinely recommended, is now being questioned following Heyman and Babayof’s comprehensive review, although they noted that the practice should not be discouraged and certainly would appear to be wise in the event that aluminum oxide particles accompany the emphysematous episode. Surgical evacuation of air has previously been reported with temporary and incomplete resolution.

As with all medicodental complications, it is important to fully communicate to the patient the nature of the swelling and the expected course. Although discomfort is generally slight when emphysema is limited to subcutaneous tissues, further deeper fascial tracking can require the administration of analgesics. Application of moist heat to the area of swelling may be helpful. Hospitalization should be considered in the presence of infection, or when there is respiratory obstruction, extreme anxiety, and debilitating discomfort.

Although peripheral to this discussion, the effect of nitrous oxide is mentioned for its exacerbating potential. If emphysema is detected at any stage during an operative procedure, the use of nitrous oxide should be discontinued because the gas will diffuse into the air spaces and increase the volume of trapped air.

Probable course of the air through the neck and thorax

The visceral spaces of the neck, retropharyngeal, vascular, and pretracheal spaces are in direct communication with the mediastinal spaces of the thorax. Subcutaneous emphysema gaining access to the interfaces of these connective tissue areas in the head and neck may follow the fascial planes, much as an infectious process would. In this patient, the air, introduced distolingually at the gingival margin proximal to the second maxillary molar, dissected backward along the connective tissue plane between the gingiva and the hard palate, then between the bed of the tonsil and the superior constrictor on the medial aspect and between the bed of the tonsil and the medial pterygoid muscle on the lateral aspect. This would then allow it access to the retropharyngeal space (a potential space, filled with areolar connective tissue, located between the superior constrictor and the prevertebral fascia) and caudally into the carotid sheaths, which are just medial and posterior to this region. The fact that there was even more air adjacent to the right carotid sheath than the left one (see Fig 5), where the technique was performed, suggests that the air crossed the midline, probably through the retropharyngeal space. This may have been a result of the extraordinarily high air pressure that was employed.

Although the sheath is thick in the carotid region, which would tend to keep the air out of the sheath itself, it is thinner near the internal jugular veins. Entry through the sheath could have been gained at this point. It was not possible, from the radiographs alone, to determine whether the air associated with the carotid sheath was actually within this structure or just surrounding it, although it seems likely that the air would have remained outside the sheath.

It was difficult to tell if the air surrounding the heart was between the sternum and the pericardial cavity or within it (see Fig 6). If the air remained outside the carotid sheath, the anatomy of this area would suggest that it lay outside the pericardial sac, because the carotid sheath fuses with the pericardium and the connective tissue of the great vessels at this point and would not allow the air access to the sac.

The fact that a pneumomediastinum was present suggests that the majority of the air lay outside the pericardial sac. If all or some of the air gained access to the inside of the carotid sheath, it may also have gained entry to the pericardial cavity alongside the great vessels.

Emphysema and air-abrasive technology

Air-abrasive technology is based on the principle of kinetic energy. Essentially, energy is related to mass in motion. In 1945 Black, in the introduction to this technology, wrote: “The air-abrasive process employs for its action a very fine—almost pinpoint—stream of compressed air into which a suitably finely divided abrasive agent has been introduced.” As an alternative to the slow-speed, belt-driven handpieces, this technology enjoyed a brief period of popularity. The first air-turbine handpiece, introduced in the late 1950s, soon overshadowed the early air-abrasive instruments, and air-abrasive technology soon lost favor among clinicians and manufacturers alike.

The adhesive revolution, with its protocol of conservative and less structured cavity preparation, together with the desire for more conservative and patient-friendly treatment modalities, has sparked a reemergence of air-abrasive technology. Although this newly revived technology incorporates a number of sophisticated and impressive technologic advances, all the devices are essentially powerful sandblasters. As
such, the technology, stripped of the bells and whistles, is crude, and clinicians need to be reminded that the intraoral application of compressed air is potentially hazardous.

All the technique manuals mention the obligatory use of dental dam; however, there is a noticeable lack of dental dam within the presentations of authors, lecturers, promoters, advertising displays, and brochures. This marketing proclivity lends credence to the safety of application in the absence of dental dam.

The air pressures employed are in some cases twice those delivered to a high-speed handpiece (up to 160 psi). Although there have been reports of subcutaneous emphysema following the intraoral use of an air-water syringe, we, as a profession are generally comfortable utilizing compressed air from this source. The pressure delivered by an air-abrasive device is readily grasped when a medium-sized latex glove is inflated; it takes a mere 3-second burst of an air-abrasive device set at 120 psi to inflate a glove. Some product brochures exult in their maximal air pressure readings and equate “higher pressure = faster cutting with less mess.” It has recently been suggested that adhesive bond strengths with air abrasion at 160 psi are similar to those obtained with acid-etching alone. It seems inevitable that future modules will be released with pressures that exceed even the current median 120 psi.

The morbidity associated with emphysema is proportionate to the amount and pressure of air delivered to the soft tissues. It air is forced into the tissues, recovery is generally uneventful, even when the air is spread via fascial tissue planes to other anatomic sites, such as the mediastinum or thorax. However, although there are many reports of dental emphysema, there have been no documented cases associated with air abrasion. One can only but speculate as to the scenario that the tip of the handpiece was inadvertently moved off the occlusal surface of the tooth adjacent to the distolinguinal gingival tissues. Air continued to be delivered at 120 psi, dissecting the tissues and causing the sudden emphysematous episode.

The manufacturers’ motivation for permitting air flow without powder has been to permit cleaning of the cavity preparation. A newly released air-abrasive device does away with the two-stage foot control but includes an additional 1.5-second continuous air flow after the foot control has been deactivated. This is potentially hazardous, because operators tend to lift the handpiece off the tooth surface as the abrasive flow is terminated.

Clinicians must be cognizant of the fact that the air pressure (up to 120 psi) is still being delivered once the foot pedal is deactivated. The handpiece nozzle must be kept away from soft tissue at all times.

**Higher air pressures a change in prognosis?**

Cervicofacial, retropharyngeal, mediastinal, and thoracic emphysematous complications originating in the oral cavity of dental patients are, for the most part, self-recovering. A reasonable concern for clinicians is the danger of upper airway obstruction. Study of the reported cases to date indicates that air dissection preferentially takes place along loose, low-resistance structures and not the relatively tight submucosa of the glottis and trachea. The operative air pressures involved in previously reported episodes have been in the range of 40 to 80 psi, well below the 160 psi now...
suggested for adequate air-abrasive "etching" of tooth structure. The sudden ballooning response witnessed in the patient in the present case report bears testimony to the potentially devastating sequela to the inappropriate use of devices with extraordinarily high air pressure. The tissue dissection may not necessarily follow the path of least resistance, as it has with lower pressures in the past. Air may accumulate in sites that could be life threatening, requiring drainage procedures.

In addition, it is relevant to note that 45% of patients with subcutaneous emphysema develop emphysema of the periorbital subcutaneous tissue. This distribution and occurrence has previously been reported to be unrelated to the location or nature of the dental treatment. The first report of partial blindness secondary to iatrogenic subcutaneous emphysema has highlighted the seriousness of this complication, because the optic nerve has little regenerative potential. The external compression of the eye can result in transient hypoperfusion of the central retinal artery and its arteriolar branches. Higher air pressures associated with preseptal lid edema may lead to fractures of the periorbital sinuses and increased compression of the eye.

Prevention of air emphysema

Clinically, these air-abrasive devices are most suitable for minimally carious, noninvasive preventative resin-type situations. Given the paucity of dental dam use with extensive restorative procedures, it is unlikely that dental dam will routinely accompany the employment of this technology. Without dental dam, vision is limited, particularly in the maxilla, because the mirror has to be kept at a distance to prevent scouring of the reflective surface from the action of the ricocheted aluminum oxide particles. Ideally, dental dam should be a prerequisite for the selection of an air-abrasive method of cavity preparation, particularly if an adhesive restorative option is proposed. The following cautionary guidelines are appropriate for all clinical procedures utilizing compressed air, given the extraordinarily high pressures that accompany air-abrasive technology:

1. The appropriate operative access should be established to permit complete visualization of the tip of the handpiece at all times.
2. Dental dam should be used whenever operable.
3. Control panel selections should be completed before the handpiece is positioned within the operative field.
4. Correctly tightened matrix bands should be used when interproximal tooth substance is cut. A tissue-displacing instrument (Zekrya, Maillefer, Caulk/Dentsply) designed for cervical retraction makes for an ideal shield for treatment of Class V lesions and defective gingivally located resin restorations.
5. The handpiece must never be directed at soft tissues, even for a brief period of time.
6. The compressed air (first stage of the foot control) must never be used to clean the cavity or working field.
7. The air-abrasive device must never be directed into the floor of a cavity when the pulpal tissues are suspected to be patent because an air embolus fatality has been reported following the use of pressurized air during an endodontic procedure.

Finally, manufacturers are encouraged to review the need for air flow without powder designed in the two-stage foot control.

Conclusion

A case detailing the consequences of careless and inappropriate application of an air-abrasive device, has been reported. It is hoped that the incident will serve to highlight the iatrogenic potential and reinforce the manufacturer's instructions regarding the correct and appropriate use of air-abrasive technology. Although it would be foolish to discontinue use of this serviceable technology, or any dental modality that introduces air into the mouth, the potential for emphysema must be considered at all times when an instrument with pressurized air is used intraorally.

Application criteria must always be judiciously followed, particularly when devices with extraordinarily high air pressure are used. The reported incident has been the only complication encountered during 24 months of routine use of the air-abrasive device.

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References


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