

E-cigarettes and wound healing

KEY WORDS

- ▶▶ E-cigarettes
- ▶▶ Respiratory illness
- ▶▶ Skin flap necrosis
- ▶▶ Wound healing

Smoking is a well-established risk factor for delayed wound healing and post-operative complications. Due to the overwhelming evidence of the detrimental health effects of smoking electronic cigarettes have become increasingly popular. The technology behind the devices has improved since their arrival in the UK and their use has been supported and encouraged by Public Health England; who stated they were 95% safer than smoking tobacco. But recent reports show a worrying link with serious respiratory illness and research has found that the nicotine, flavourings and diluents used in the e-cigarette fluids can have similar effects as tobacco on wound healing by increasing the risk of skin flap necrosis and hypoxia, with detrimental changes to the immune cells which aid healing. The recommendation is that patients should not be advised to use e-cigarettes as an alternative to conventional cigarettes prior to elective surgery.

The detrimental effects of tobacco smoking on the respiratory and cardiovascular systems are beyond question (Godtfredsen and Prescott, 2011), with the knowledge that tobacco smoke constituents enter the blood stream with widespread effects to every organ in the body (Cope, 2016).

Another important effect of smoking is to retard wound healing and increase the risk of scarring, post operative complications and an enhanced risk of diabetic foot amputation (Liu et al, 2018). Specific to plastic surgery procedures, nicotine is known to increase the risk of skin flap necrosis and surgical site infection (Knobloch et al, 2008). While smokers undergoing transverse rectus abdominis muscle (TRAM) breast reconstruction also have higher rates of mastectomy and abdominal skin flap necrosis (Chang et al, 1996). Similarly, smokers who undergo head and neck reconstruction have significantly higher wound complications (Marin et al, 2008).

Tobacco smoke-derived chemicals have been shown to be detrimental to tissue oxygenation, with carbon monoxide (CO) binding with haemoglobin to reduce the oxygen-carrying capacity of the blood (*Figure 1*). The immune response is also compromised, with impairment of leukocyte, chondrocytes and fibroblast activity, leading to necrosis, inadequate microbial eradication and deficient collagen production (Cope, 2014). Consequently, a number of NHS

Trusts have implemented a refusal to carry out surgery on patients who continue to smoke following advice to quit prior to the elective procedure (Donnelly, 2017).

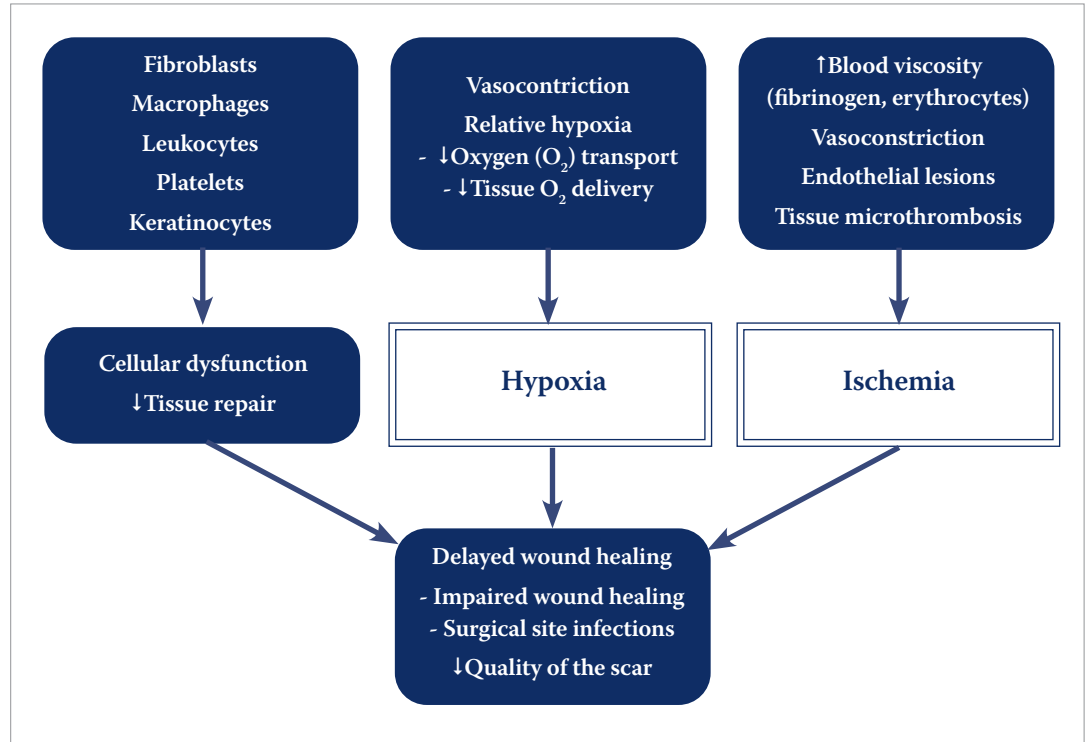
ELECTRONIC CIGARETTES

Knowledge about the harmful effects of smoking has become a major concern to the general smoking public. This, together with government initiatives to prevent smoking in public spaces, no tobacco on view at point of sale and graphic images on cigarette packets has gradually turned people away from tobacco, to the point where in 2018 only 15% of adults smoked cigarettes on a regular basis (ONS, 2018).

However, the human urge for the addictive substance nicotine has not declined and the invention of electronic cigarettes in 2003 and their emergence onto the UK market in 2011 (Brown et al, 2020), provided an attractive alternative to certain groups, particularly the 25–34 age range (ONS, 2019).

Initially, the devices were cigarette look-alikes that utilised an electric element to vaporize a nicotine containing liquid of propylene glycol, but now the shape and delivery systems of these products varies widely. The vapour produced is frequently flavoured to mimic exotic fruits or sweet foods and the modern terminology is vaping. Public Health England (PHE) came out

Figure 1. Hypoxia, tissue ischemia and immune disorders induced by tobacco consumption cause alterations of the healing process (adapted from Pluvy et al, 2015)



in support of these devices, saying they were 95% safer than combustible cigarettes and suggested that e-cigarettes may be contributing to falling smoking rates among adults and young people and they potentially offer a wide reach, low-cost intervention to reduce smoking in more deprived groups in society where smoking is elevated (Gov.uk, 2015).

While it was undeniable that e-cigarettes are safer than combustible cigarettes (Gov.uk, 2015) their efficacy as a smoking-cessation aid and the potential long-term toxicity of the flavourings was widely questioned. To provide a better understanding of the complexities of this topic the House of Commons Science and Technology Committee (HoCSTC) held an enquiry with a series of interviews with 25 witnesses from academia, the public health sector and commerce, and considered over 100 written submissions of evidence. They reviewed how e-cigarettes could reduce smoking-related harm, their role in smoking cessation and future regulations (HOCSTC, 2018).

The conclusions of their report were that e-cigarettes represented an opportunity to accelerate already declining smoking rates. They reduced the exposure to second-hand tobacco smoke and the evidence showed that the exhaled vapour from

these devices to be harmless. However, there were uncertainties about any long-term health effects. This is largely because the products have not been available for long enough and they have not been used by individuals who have not been previously damaged by conventional cigarettes.

Currently, adverts for vaping are banned in the UK's mass media but there are influential, indirect promotions on certain social platforms. E-cigarettes can be legally promoted via billboards, flyers and in shops that sell tobacco, vaping paraphernalia and liquids. But the news of the launch of the JUUL brand (Juul Labs, Inc) in the UK in July 2018 caused a furore because this format had been strongly linked to adolescent use of vaping, due to its small, indiscrete size (Reuters, 2018). So the use of these devices continues to grow.

E-CIGARETTE CONSTITUENTS AND EFFECTS

The heating of nicotine-containing liquids of glycerine or vegetable-based glycerol has been shown to provide the same level of plasma nicotine as conventional tobacco smoking (Rhoades et al, 2019), but without the cancer-causing nitrosamines, tar or the oxygen-starving carbon monoxide from

the gases produced. Therefore, the users should be at much lower risk of lung disease, cardiovascular disease, with a reduced detrimental effect on pregnancy and fewer post-operative complications.

However, in recent months, more than 200 possible cases of acute lung injury, potentially associated with vaping were reported across the USA (Davidson et al, 2019). The adult patients experienced several days of worsening difficulty with breathing, nausea, vomiting, abdominal discomfort and fever, with a diagnosis of lipoid pneumonia. Most had a history of using marijuana oils or concentrates containing tetrahydrocannabinol (THC) in the e-cigarette devices, but not all. One potential explanation for this acute effect is that aerosolized oils inhaled from e-cigarette liquids, whether containing THC or not, are deposited within the distal airways and alveoli, inciting a local inflammatory response that impaired vital gas exchange (Davidson et al, 2019).

EFFECTS ON WOUND HEALING

The evidence of detrimental effects of e-cigarette use is starting to emerge, which suggests that vaping may induce some of the same physiologic changes as traditional cigarettes, and may have a significant deleterious effect on wound healing (Fracoll et al, 2017), particularly that involving skin flaps (Rau et al, 2017). This study found both the medium-content and high-nicotine content e-cigarette exposure groups had similar amounts of flap necrosis and hypoxia when compared with the tobacco cigarette exposure group. Therefore, smoking and vaping appear to be equally detrimental to wound healing and to be associated with a statistically significant increase: $p < 0.05$ (Rau et al, 2017) in flap necrosis compared with the unexposed group. The results suggest that vaping should not be seen as a better alternative to cigarette smoking in the context of wound healing and should not be advised as an alternative (Troiano et al, 2019).

The lack of CO generation by e-cigarettes suggests users would have a better post-operative outcome with regard to tissue oxygenation. However, human studies have shown that e-cigarettes users have similar detrimental outcomes on oxygen supply and other effects to the skin as traditional cigarettes (Page et al, 2016). This

may be because e-cigarette vapour has been shown to induce alterations in a variety of immunological cell types, neutrophils, macrophages and keratinocytes, with changes to the production of pro-inflammatory cytokines and the consequential inhibition of defences against bacteria and viruses, increasing the risk of hospital-acquired infections such as MRSA (Hwang et al, 2016). This leads to suboptimal skin and bone growth (Chen et al, 2019). These effects are not only due to the effects of nicotine but also to the humectants (glycerine and glycerol), different flavourings and other constituents of e-cigarettes, which have been shown to increase free radical attack and inflammation (Chen et al, 2019). These immunological effects may also be partially responsible for the harmful effects of e-cigarette vapour on respiratory and cardiovascular physiology (Kaur et al, 2018).

BIOMARKER TESTING

Payne and Southern (2006) discussed that due to the associated guilt and a failure to respond to anti-smoking advice before surgery, particularly plastic surgery, self-reported information about smoking habit and cigarette consumption can be inaccurate and subject to bias. Yet accurate assessment of smoking history at point-of-care is valuable to assess nicotine intake three days prior to testing. The most common method employed is expired-air carbon monoxide monitoring (Grant et al, 2015). However, e-cigarettes do not generate CO and so this method is inappropriate. As most e-cigarettes used contain nicotine then the best method is cotinine testing (Reinbold et al, 2015). This can be done relatively inexpensively with point of care testing, using urine or saliva (Cope et al, 2012). This has been advocated prior to total joint arthroplasty, as it significantly improves the self-reported quit rates of smokers before surgery and helps identify the 15% who falsely report abstinence to ensure appropriate counselling of inherent risks (Hart et al, 2019).

Nurses involved in wound care should continue to ask about the patient's smoking status but they must also enquire about their use of e-cigarettes. It should be pointed out that any intake of nicotine could be detrimental to their wound care, including nicotine replacement therapy (NRT) (Michaels et al, 2018), and cessation of both smoking and vaping should be strongly encouraged (Troiano et al, 2019).

CONCLUSION

Given that many smokers undergoing elective surgery have expressed interest in using e-cigarettes as a means to abstain from smoking in the perioperative period, more data about their safety must be evaluated (Kadimpati et al, 2015). Despite limited objective data, current evidence suggests e-cigarettes may induce some of the same physiologic changes as traditional cigarettes, with or without nicotine present, and may have a significant deleterious effect on wound healing and should not be recommended. Despite limited objective data, current evidence suggests e-cigarettes may induce some of the same physiologic changes as traditional cigarettes, with or without nicotine present, and may have a significant deleterious effect on wound healing and should not be recommended. Patients should be informed about the deleterious effects of smoking and vaping and total abstinence would produce the best outcome for their surgical operation. If this proves difficult then the patient should be advised the cravings can be alleviated with limited use of short-term nicotine replacement therapy such as gum and lozenges which can be obtained without a prescription.

WUK

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