
The Dangers of Peri-operative Smoking in Orthopaedic Surgery

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Abstract

Tobacco smoking is a major worldwide hazard. It has been proved that its detrimental effects are due to nicotine and carbon monoxide, which impair the microcirculation and tissue oxygenation. Smoking adversely affects bone mineral density, increases the incidence of hip fractures and alters bone and wound healing processes. Tobacco has been proved to be a factor in causation of post-operative complications, cardiopulmonary failure, soft tissue and bone infection and delayed union or non-union. A systematic smoking-cessation programme should be observed from at least 6 weeks prior to surgery by all involved professions.

Introduction

People have become aware of the various harmful effects of smoking since a definitive association was established in the 1960s between tobacco smoking and lung cancer. Physiological effects of nicotine and other products found in cigarette smoke are more and more well known by scientists and information has been publicly propagated widely. Moreover the alarming reference work of Robert Proctor [50] has revealed how cigarettes

came to be the most widely used drug source on the planet thanks to more than a century of manipulation by the tobacco industry. Also, big tobacco manufacturers continue to deny the negative effects of smoking by intensive publicity and collusion with some scientific and political agencies. Nonetheless, the detrimental effects of cigarette smoking on post-operative outcomes are yet underestimated by surgeons and patients although a considerable literature and consistent studies have been published since 2000. All surgical specialities are concerned but this paper aims to inform more specifically Orthopaedic surgeons by reporting the general physiological effects of cigarette smoke, the musculo-skeletal effects of cigarette smoking, the existence of peri-operative complications directly resulting from cigarette smoking, the effects of cigarette smoking cessation and how to help smokers to quit around the time of surgery.

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Physiological Effects of Cigarette Smoking

Cigarette smoke consists of two phases:

- A volatile phase which contains nearly 500 gases (e.g. carbon monoxide, benzene.)
- and a particulate phase of approximately 3,500 chemical products which contains nicotine and carcinogenic substances.

Nicotine is now considered as the principal addictive component of cigarette smoke. It has a half life of 3 h and is metabolized by the liver, giving the nicotine which can be used to evaluate recent cigarette smoking by detecting it in a smoker's urine. Nicotine is responsible for vascular disturbances by stimulating the sympathetic nervous system.

Carbon monoxide reduces the amount of oxyhaemoglobin by taking the place of O₂. Combined action of nicotine and carbon monoxide decreases tissue perfusion and oxygenation, increases platelet aggregation and blood viscosity resulting in microclotting [5].

The immune system is impaired by cigarette smoking: white blood cell functions and antibody responses are decreased and the T-lymphoblasts are inhibited in the cell cycle. Paradoxically the level of auto-antibodies tends to be increased in smokers, notably antinuclear rheumatoid factors which are involved in rheumatoid polyarthritis [41, 61].

General Musculo-Skeletal Effects of Cigarette Smoking

Bone metabolic activity is reduced in smokers by the combined action of reduced blood supply, tissue hypoxia and effects on arteriolar endothelial receptors. The role of smoking has been incriminated in the development of osteonecrosis of the femoral head in adults and Legg-Calvé-Perthes' disease in children [6, 19, 22].

The effect of nicotine on osteogenesis and osteoblast formation appears paradoxical and to be dose-dependent. Osteoblast formation and function are inhibited at high levels of circulatory nicotine, whereas they are stimulated at low levels [3, 14, 23, 52]. In a study on rats, nicotine

alone did not affect mechanical properties of healing femoral fractures, whereas tobacco extract not containing nicotine significantly reduced it [58]. Different studies suggest that nicotine replacement is safe with regard to bone healing and may even accelerate fracture healing with a dose-dependent effect [36].

On the other hand collagen synthesis is impaired by exposure of osteoblast-like cells to high concentration of both nicotine and cigarette smoke [17, 26]. Carcinogens in cigarette smoke inhibit osteoblast formation and differentiation. Another negative effect of smoking on bone may be the depletion of bone marrow by T3 lymphocytes inducing decreased calcium absorption in smokers which may also be a factor of decreasing bone formation and increasing resorption [18, 32]. Smoking has also been involved in disturbances of sex hormones; female smokers tend to enter the menopause 2 years earlier than non-smokers [40, 43]. The level of osteocalcin which is secreted solely by osteoblasts and used as a marker of bone formation is decreased in recently menopausal female smokers [24]. Increased resorption and decreased formation result in significant deleterious effects on BMD even in young people [39]. All these harmful biological effects increase the risk of fractures amongst smokers. Meta-analysis of prospective studies demonstrated an independent association between smoking and hip fracture risk both in men and women (RR = 1.85) [28, 33].

Peri-operative Complications in Orthopaedic Surgery

One should differentiate general complication and local complications at the surgical site. The most common complications associated with smoking are wound healing, infection, delay in bone healing and cardio pulmonary complications.

General Complications

Tobacco smoking is one of the most important risks of cardiac and pulmonary diseases. Smokers who undergo a general anaesthetic have an increased

risk of complications which is associated with pulmonary and cardiac diseases and not directly linked with tobacco smoking [15, 46]. Nonetheless differences between past and current smokers have been found, which indicate a statistically significant decrease in pulmonary complications for the former [55]. No difference between past and current smokers has been found on mortality.

The average length of stay was reported to be increased in current smokers. The duration of hospital stay was linked both to general complication and local complications [55].

Local Complications

Soft Tissue Healing and Wound Infection

Smokers are known to be at increased risk for wound and soft tissue complications as compared with non smokers [47]. Cigarette smoke induces an alteration of the normal process of healing by disturbing the function and the migration of fibroblasts, mesenchymal stem cells, acute-phase proteins and growth factors [63]. Moreover smoke creates free radicals which cause direct cellular damage [51]. Increased risk to free and local flaps and digit replantation failures among smokers has been observed [5, 11, 53] but surprisingly, the rate of micro-vascular anastomosis failure was not found significantly increased by smoking [34]. Tendon healing and ligament healing appear to be affected by cigarette smoking in experimental studies involving rats or mice [20]. Degenerative tears of the rotator cuff were found to be more prevalent and longer-lasting in smokers with a dose and time-dependent relationship [7, 27]. In one series smokers also had a 7.5 times higher risk of distal biceps tendon rupture [56]. According to several studies smoking altered significantly the long term outcome in primary anterior cruciate ligament reconstruction [29, 31, 60]. A randomised study performed on healthy voluntary adults, who had experimental an incision just lateral to the sacrum, showed a higher rate of infection in smokers whereas 4 weeks of abstinence reduced wound infection to the level of a non-smoker [59].

Delayed Bone Union or Non-union

Association between smoking and spinal fusion non-union has been well described by Brown et al. [8] who found the rate of non-union to be five times higher in smokers. This conclusion was confirmed by other studies [4, 21]. Osteotomies and joint fusion have been found to be associated with an increased risk for delayed union or non-union in smokers compared with non-smokers. This concerns particularly healing of ulna shortening osteotomy for carpal impaction (7.1 months in smokers vs. 4.1 months in non-smokers) [12], ankle joint fusion with a risk of non-union in smokers 3.75 times that of non-smokers [13], hind foot fusion with a risk of non-union in smokers to be 2.7 times state of non-smokers [25]. In patients who underwent an osteotomy for knee deformity, time of healing was longer in smokers than in non-smokers [62]. Risk of scaphoid non-union after surgical treatment in smokers was 3.7 times that of non-smokers [37].

Although the detrimental effect of smoking on fracture healing may not be due to nicotine, several retrospective studies have found that fractures are more prone to worse outcomes in smokers [1, 2, 13, 45, 57]. Operative management of Ankle fractures is associated with a six times greater risk of delayed or non-union in smokers than in non-smokers [48]. Finally, smokers are 3.7 times more likely to develop a bone infection [9] and 3.8 times more likely to develop a non-union [10, 16].

Smoking Cessation Reduces Peri-operative Complications

The effects of smoking may at least be partially reversible. Immune functions appear to recover after 6 weeks of abstinence, wound healing after 3–4 weeks, pulmonary function after 6–8 weeks [55]. A recent review of six randomized trials on the effect of cessation showed a relative risk reduction of 41 % for post-operative complications with each week of cessation prior to surgery increasing the magnitude of effect by 19 % [44].

Trials of at least 4 weeks smoking cessation had a significantly larger treatment effect than shorter trials [49]. Observational studies demonstrated relative risk reduction of 0.76 on total complications with a longer period (more than 4 weeks) cessation, producing an average 20 % larger reduction in complications than shorter periods. Two randomized smoking cessation studies involved Orthopaedic patients.

In the first one the group of patients who undertook 6–8 weeks of smoking cessation prior to their operation had significantly fewer complications requiring treatment as compared with a control group of smokers particularly with regard to wound complications [46]. In another study of randomized patients undergoing hip or knee replacement and other operations (hernia repair, laparoscopic cholecystectomy) post-operative complications were reduced from 42 % in the control group (smokers) to 21 % in the intervention groups (6 weeks smoking cessation programme). Abstainers had fewer complications than those who only reduced smoking or those who continued to smoke [38].

Encouraging Patients to Stop Smoking Pre-operatively

From a general point of view, the attitude of physicians has increasingly changed over the last 10 years. Before 2000, retrospective studies had shown a correlation between negative effects and surgical outcomes, but level of proof was weak and a true uncertainty remained. A precautionary approach was generally taken and consisted of simply advising candidates for surgery to quit or to reduce smoking. Since 2000, prospective and randomized studies have resulted in the same conclusion with a high level of proof: tobacco smoking in the peri-operative period increases the risk of general and local complications. Uncertainty has been removed and the precautionary approach which is indicated in uncertain situations has become obsolete. Medical Doctors involved in peri-operative management have now, not only to inform the patient but also, and chiefly, to propose and undertake preventive

actions. This means helping the patient to stop smoking in order to decrease the risk of adverse outcomes.

Elective surgery offers a great opportunity for physicians to help smokers stop, as peri operative smoking is linked to surgical complications including wound infections, cardiac and pulmonary functions, prolonged hospital stay, general infections and vascular or intestinal anastomotic leaks. Recent study [42] undertaken by the French Society of Orthopaedic and Traumatology (SOFOT) confirmed that most of surgeons do not seize this opportunity [54]. One important reason may be the lack of awareness since surgeons and patients are often not fully informed of the detrimental effects of smoking on surgical outcomes. Other reasons include time constraints, lack of expertise in cessation counselling and sometimes a perceived lack of effective smoking cessation interventions. Although many interventions are available (nicotine replacement, behavioural feed-back,) convincing a smoker to quit in the time before surgery is challenging. The announcement of surgery may increase the desire to smoke in anxious patients. Other obstacles can arise since surgeons may find cancelling an elective operation both frustrating and costly. On the other hand, a patient who is refused an operation by surgeon can find a different surgeon willing to perform the procedure. Refusing to operate on a smoker may appear as a possible discrimination. But one should remind all patients that operating on active smokers results in higher health care costs and higher risks of surgical complications.

In fact, arranging appropriate smoking cessation services need not be complicated or time intensive [35]. Surgeons should use the Ask-Advise-Refer strategy, in identifying surgical candidates as smokers and refer them to other trained professionals such as the patient's primary care physician, respiratory therapists, toll-free telephone quit lines or web programmes. The dilemma of a National health service is between an authoritative demand for smokers to quit and the option to provide incentive-based cessation programmes for patients to quit smoking [30].

Informations and assistance to quit smoking is relatively easy to manage in elective surgery. When the surgeon meets a patient for a consultation for the first time, the “four rules” recommendations can easily be applied:

- Is the patient smoking?
- If yes, the addictive dependency must be assessed by the shortened Fagerström test which comprises the quantity of cigarettes per day and the delay between waking and the first cigarette. A delay of less than half an hour suggests a strong addictive dependency to nicotine.
- To explain to the patient the increased relative risk of wound necrosis, superficial and deep infections and delay in bone union; which is multiplied by 3, compared with non-smokers.
- To propose gently a programme of smoking cessation 6 weeks before surgery, based on nicotine patches. Controversies have arisen about the role of e-cigarettes and their efficacy in smoking cessation and in harm reduction. Their long term safety is also discussed. Nonetheless, in the context of minimal support, e-cigarettes are at least as effective as nicotine patches and are a cheaper alternative.

The most difficult situation is probably the management of a smoker in an emergency just after trauma. Physiological and psychological consequences of the trauma, anxiety resulting from the announcement of imperative surgical treatment, obligation to remain on an empty stomach, and withdrawal symptoms, often result in aggressive behaviour which increases the risk of complications. The solution is to undertake emergency replacement nicotine therapy, before surgery.

Surgeons must be aware that surgery is a powerful opportunity to help patients quit smoking. Patients and physician should be convinced by the evidence that pre-operative smoking cessation is safe and significantly reduces complications and length of hospital stay. National surgical professional societies should promote greater use of the AAR strategy. Collaborations with primary care physicians, anaesthesiologists, and other involved professions can facilitate smoking cessation.

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