Second-hand smoke, public smoking ban and acute myocardial infarction

A brief review of the literature with emphasis on the Swiss experience

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Summary

Tobacco use is one of the most important avoidable causes of cardiovascular diseases worldwide and is one of the most important causes of acute myocardial infarction globally, especially in men. Active and passive smoking increase the risk of coronary artery disease and the risk of acute myocardial infarction. There is substantial evidence that the cardiovascular system is exquisitely sensitive to the toxins produced by second-hand smoke through different mechanisms (increased platelet activation, endothelial dysfunction, oxidative stress, inflammation among others). Multiple studies in various countries indicated that reducing the exposure to second-hand smoke by implementation of regulations to ban smoking in public buildings is followed by a rapid reduction in the number of hospital admissions for acute coronary syndromes. Insofar as the smoke-free policies can offer a simple and inexpensive intervention for the prevention of cardiovascular diseases they should be included in prevention programmes worldwide. In this review we summarise several pathophysiological aspects of second-hand smoke, and refer to the epidemiological data of the literature also alluding to the peculiar federal Swiss situation including our own experience in Southern Switzerland, at a time when an animated public debate on nationwide smoke ban legislation is very hot.

Key words: STEMI; smoking ban; second-hand smoke

History of tobacco

Tobacco is a plant that is indigenous to North and South America. It is in the same family as the potato, pepper and the deadly nightshade, a very poisonous plant. Tobacco smoking is the practice where tobacco is burned and the resulting smoke is inhaled. The practice may have begun as early as 5,000–3,000 BC. On 15 October 1492, Christopher Columbus was offered dried tobacco leaves as a gift from the American Indians that he encountered and tobacco arrived in Europe as an eccentric fashion restricted to a small élite. Historically, Pope Urban VII gave way to the world's first know public smoking ban in 1590, as he threatened to excommunicate anyone who "took tobacco in the porchway of or inside a church, whether it be by chewing it, smoking it with a pipe, or sniffing it in powdered form through the nose" [1–3].

Epidemiology

Tobacco use is one of the most important avoidable causes of cardiovascular diseases worldwide [4]. The number of smokers worldwide is currently estimated to be 1.3 billion, of which 82% are in developing countries [5]. In Switzerland, every year about 9,000 people die due to tobacco use and 47% of the deaths are related to cardiovascular disease [6]. Epidemiological evidence has unequivocally confirmed that active smoking is a risk factor for cardiovascular disease and the leading cause of preventable death [5]. Second-hand smoke (SHS) increases the risk of acute myocardial infarction (AMI) by 25%, to 31%, accounting for at least 35,000 deaths annually in the United States [7–11]. In countries where smoking prevalence is high (Britain, Europe and Greece), AMI incidence in non-smokers is noticeably higher [12]. Protection of non-smokers through smoke-free environments leads to a decrease in heart disease mortality through a combination of reduced exposure to SHS and an environment that makes it easier for smokers to stop smoking [13]. The INTERHEART study, a case-control study of 15,152 cases of

Funding / potential competing interests:
No financial support and no other potential conflict of interest relevant to this article were reported.

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first AMI and 14,820 age-matched and sex-matched controls, clearly confirmed that the use of tobacco is associated with increased risk of AMI, consistently across all regions of the world. The risk was greater for younger people than for older people. The risk was also higher for males than for females. Bedsides the magnitude of risk was shown to be closely and linearly related to the number of cigarettes smoked, and former smokers had a higher risk of AMI than did non-smokers, but this risk decreased after stopping smoking. Finally, exposure to SHS increases the risk of AMI, in non-smokers and former smokers [4].

Cardiovascular effects of second-hand smoke

In general, SHS has two main components, sidestream and mainstream smoke. Sidestream smoke emerges from the tip of a burning cigarette, accounting for 85% of the total amount of SHS. The remaining 15% is made up of mainstream smoke, which has been inhaled and is exhaled by an active smoker [14]. Low tar cigarettes and smokeless tobacco have been shown to increase the risk of cardiovascular events in comparison with non-smokers [15, 16]. Furthermore, SHS with a smoke exposure about one-hundredth that of active cigarette smoking is associated with approximately a 30% increase in risk of coronary artery disease, compared with an 80% increase in active smokers [7, 8]. Mechanisms by which SHS is likely to contribute to acute vascular events include induction of a hypercoagulable state, increased myocardial work, carbon-monoxide-mediated reduced oxygen-carrying capacity of the blood, coronary vasoconstriction, and catecholamine release (fig. 1) [14, 17]. Moreover, SHS could accelerate atherosclerosis by a variety of mechanisms. Some of those more prominently mentioned include adverse effects on lipids, producing endothelial damage or dysfunction, or both, haemodynamic stress, oxidant injury, neutrophil activation, enhanced thrombosis and increased fibrinogen and blood viscosity [17]. Even brief exposure to smoke can cause platelet aggregation and other haemodynamic changes responsible for the development of acute ischaemic heart disease [14]. Such acute effects are probably transient and disappear within a short time (hours to days) after cessation of the exposure [17]. SHS increases cardiac risk through both chronic (atherosclerosis) and acute (platelet activation, endothelial dysfunction) pathways [18].

Table 1
Effects of second-hand smoke in the cardiovascular system [17].

Platelet activation
Endothelial dysfunction
Atherosclerosis:
– low HDL levels
– plaque instability
– increased oxidized LDL
Increased oxidative stress
Decreased energy metabolism
Increased insulin resistance
Outcome measures:
– increased infarct size
– decreased heart rate variability
– increased arterial stiffness
– increased risk of coronary disease events

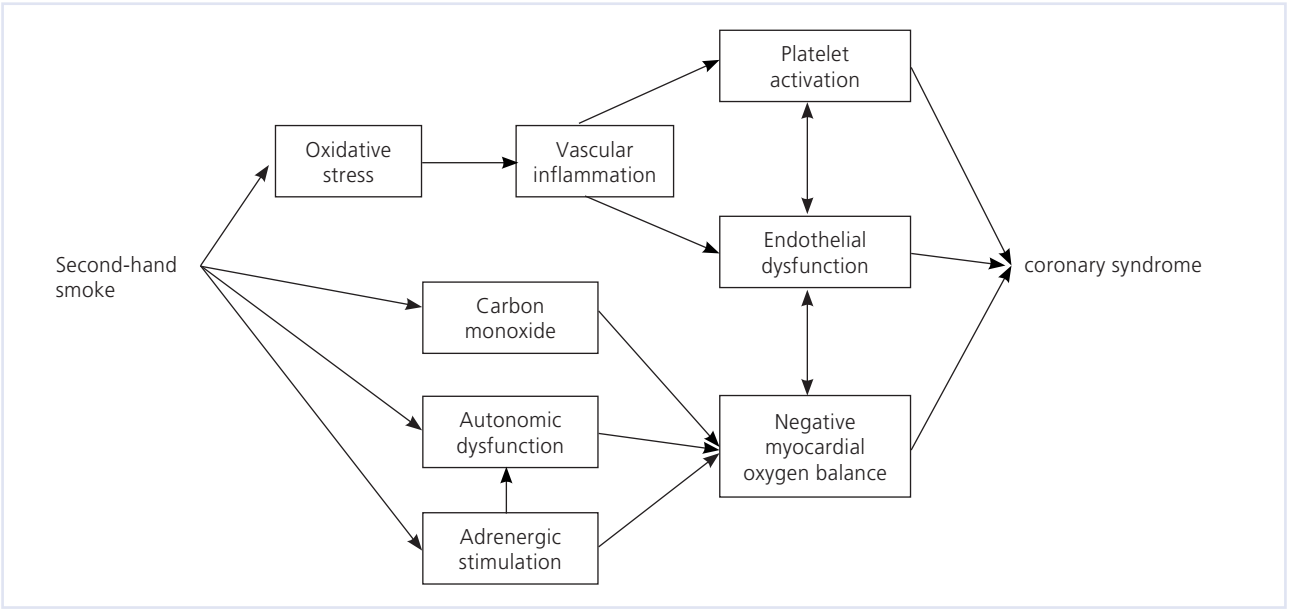

Figure 1
Second-hand smoke and coronary syndrome: the mechanisms.

Table 1 summarises the effects of SHS on the cardiovascular system.

Endothelial dysfunction

As mentioned above tobacco smoking plays an important role on the endothelial function. The endothelium is the first layer in the arterial bed that is in contact with the blood and it maintains vessel integrity, and controls vascular tone and is firstly involved in case of vascular inflammatory process [19]. The endothelial dysfunction contributes to atherosclerotic plaque formation and progression, plaque rupture, and decreased blood flow because of thrombosis and vasospasm, leading ultimately to cardiovascular disease [20]. Individuals who stopped smoking experienced a significant improvement in endothelial function, despite gaining weight, highlighting an important pathophysiological relationship among cigarette smoking, arterial dysfunction, and risk factors for cardiovascular disease among current smokers and individuals who quit smoking [21]. SHS has immediate effects on endothelium-dependent vasodilation [22]. Chronic SHS exposure has deleterious effects on endothelium-dependent vasodilation [17] and the level of endothelial dysfunction observed in passive smokers is comparable to the dysfunction observed in active smokers in both short- and long-term settings [17].

Platelet function

Platelet activation and thrombosis at sites of vascular injury or atheromatous plaque disruption play a crucial role in the pathophysiology of acute coronary events [23]. The first mechanistic evidence explaining why SHS leads to an increase in the risk of heart disease incidence or death came from studies on platelet activity. Platelet activation in response to SHS was first evaluated in an experiment that exposed smokers and non-smokers to 20 minutes of SHS [24]. At baseline, platelet activation among smokers was higher than activation in non-smokers. After the experiment, activation remained the same in smokers but was significantly increased in non-smokers, to the point that their platelet activation was not discernibly different from that of the smokers. In vitro experiments, extracts of sidestream smoke, show that, at equal doses, sidestream smoke is a more potent platelet activator than extracts of mainstream smoke. Rubenstein et al. [25] exposed human platelets to sidestream and mainstream smoke extract from 1 Marlboro cigarette. Platelet activation was evaluated under static and flow conditions (blood flow increases platelet activation). Under both conditions, sidestream was about 1.5 times more potent than mainstream smoke in activating platelets. Fibrinogen, a mediator of platelet activation and an inflammatory marker associated with a higher risk of heart disease [26], is elevated in passive smokers [10]. Thromboxane, another marker of platelet activation, is also increased in passive smokers, in some cases to levels observed in active smokers [27]. Platelet activation, however, is not the only player in thrombus formation. Blood vessel integrity is vital to prevent thrombus formation. Platelets activated by SHS also damage the endothelium, a vital layer of the arterial wall.

Effects on HDL

In addition to endothelial damage and platelet activation, passive smokers are at increased risk of heart disease because SHS accelerates the development of atherosclerosis [28]. HDL is vital in preventing atherosclerosis and low HDL levels have been associated with an increased risk of heart disease [29]. Passive smoking leads to lower levels of HDL in adults. Passive smokers (exposed to SHS for ≥6 hour/day for ≥4 day/week for at least the past 6 months) had HDL levels of 48.26 ± 3.47 (mean ± SD) mg/dl compared with 55.59 ± 4.24 mg/dl in those unexposed to SHS [30].

Other effects of second-hand smoke

Inflammation is a precursor of atherosclerotic plaque [31]. Both, passive smoking children and adults have higher levels of inflammatory markers and human and animal data support the conclusion that SHS exposure increases inflammation, which is another potential mechanism by which SHS causes heart disease. Besides, SHS contributes to the progression of atherosclerosis, and (in animal models) to an increase of the size of myocardial infarction. SHS reduces heart rate variability [32]. Heart rate variability, the beat-to-beat variations in heart rate reflected in the R–R interval variation in the ECG, gives information about the propensity toward malignant ventricular arrhythmias and cardiac death [33]. Two hours of exposure was associated with a 12% reduction in heart rate variability. This reduction has been associated with an increased risk of ventricular fibrillation or ventricular tachycardia in patients after a myocardial infarction or in those with chronic heart failure. During the subsequent 2 hours when the subjects were out of the smoking room, the heart rate variability returned to baseline [32].

Cardiovascular effect of bans on smoking in public places worldwide

Since the risk of AMI associated with smoking dissipates substantially after smoking cessation, public-health efforts to prevent people from starting the habit, and promote quitting in current smokers, will have a large impact in prevention of AMI worldwide [4]. Epidemiological studies have clearly demonstrated that

there is a decrease in risk of ischaemic heart disease within some months after the cessation of exposure to active and passive smoking [34, 35]. Laws to reduce second-hand smoke exposure are associated with rapid reductions (8%–40%) in hospitalisations for acute myocardial infarction [36, 37].

South Africa was the first country in the world to ban smoking in all public areas. Furthermore, states (such as California) and cities (such as New York City) in the USA instituted smoking-free regulations before European countries did. Ireland was the first country in the Northern Hemisphere to ban smoking in all enclosed spaces in 2004. Ireland, thereby, became a leading model for Europe regarding smoking regulations. Since then further European countries [38] and some cantons in Switzerland have instituted smoke-free legislations.

USA

One of the first studies about the incidence of AMI after smoking ban was conducted in Helena, Montana (USA), a community of 47,154 persons. This community introduced a ban on public smoking in June 2002, which was suspended in December 2002 [37]. The incidence of AMI, decreased from 170 to 102 cases/100,000 person-years, then returned to baseline, a 40% temporary decline. In the surrounding area, incidence increased from 118 to 172 cases/100,000 person-years, an increase of 46%. This was the first and lone study of a public smoking ban and the only study to include data from after a ban was suspended.

The largest population studied was conducted in many communities in New York State (population 18,976,457) which had banned public smoking, and simultaneously the NY State had increased taxation on tobacco before July 2003; the ban included implementation of a state-wide ban on work and public places (bars, restaurants, and hospitality venues) [39]. The AMI incidence decreased by 8%, from 483 to 445 cases/100,000 person-years. Compliance with the ban was 93%. From 2002 to 2004, New York City smoking prevalence decreased from 21.5% to 18.5% [38]. Exposure, as measured by salivary cotinine, decreased by 47% [41].

Europe

Italy

Italy banned smoking in cafes, restaurants, bars, and discos in January 2005. In Piedmont, an Italian region with a population of 4,300,000 inhabitants, the investigators observed before the ban an average of 3,581 AMIs between February and June 2004 (200 cases/100,000 person-years). During the comparable five months of ban enforcement, 3,655 cases were reported (204 cases/100,000 person-years) [42]. The ban in Italy was almost universally observed [43], nicotine vapour in public places decreased by 90% to 95% [44], cigarette sales declined by 8.9%, and cigarette consumption decreased by 7.6% [43]. In another city of Italy, Rome, with a population of 2,663,182 inhabitants, other investigators identified all hospital admissions with a primary or secondary diagnosis of acute coronary syndromes (ACS), including AMI, other forms of ischaemic heart disease and all out-of-hospital deaths caused by ischaemic heart disease, among persons >34 years of age before and after enactment of the smoking ban [35]. Pre-ban incidence was 252 cases/100,000 person-years. During the ban, incidence was 253 cases/100,000 person-years. Incidence decreased significantly in 35- to 64-year-old men (IRR: 0.89, 95% CI: 0.85 to 0.93) and in 65- to 74-year-old men (IRR: 0.92, 95% CI: 0.88 to 0.97), but not in 75- to 84-year-old men (IRR: 1.02, 95% CI: 0.98 to 1.07). Decreases occurred in indoor particle and urinary cotinine concentrations and per capita cigarette sales, whereas nicotine replacement products sales increased [45, 46].

Scotland

The only prospective study using both direct and indirect measurement of exposure was conducted in Scotland. Since March 2006, smoking has been prohibited in all enclosed public places in Scotland (population 5.1 million). Investigators identified all patients admitted to nine hospitals for a diagnosis of ACS from June 2005 through March 2006 and for the corresponding ten months after ban institution [47]. Results were compared with admissions in England, which did not have a ban. In the 10 months before the ban, 3,235 patients were admitted for ACS and after the ban, 2,684 patients were admitted and then a 17% decrease of ACS (95% CI: 16% to 18%) was observed. While England experienced only a 4% decrease of cases of ACS, in Scotland, admissions decreased by 14% in smokers, 19% in former smokers, and 21% in never smokers. The investigators estimated that 67% of the admissions prevented involved non-smokers. Non-smokers reporting exposure to SHS decreased from 43% to 22%. SHS in bars decreased by 86% within 2 weeks of ban implementation [48].

Switzerland

The canton of Ticino was the first area in Switzerland to introduce a new law aimed to ban smoking in all public places, including all the public administrative buildings, offices, hospitals, as well as cafes, bars, restaurants, and discos. This law was introduced on 12 April 2006 with a provisional ban and a definitive ban since 12 April 2007 [49]. In a prospective analysis started at the beginning of the smoking ban we observed a rapid, significant, and long-term reduction in hospitalisation for STEMI among residents of canton

Ticino in Southern Switzerland, with a mean reduction of 20.9% during the first three years after the implementation of this law when compared to the incidence assessed retrospectively during the three years preceding the introduction of the smoking ban [50]. After canton Ticino the smoking ban in public places was introduced in 2008 by canton Graubünden, where an overall 22% reduction in the rate of acute myocardial infarction was observed within the first and second years after enactment of the public smoking ban [49, 50]. Besides, Trachsel et al. observed a reduction of STEMI (17%) similar to our results one year after the introduction of a smoking ban in canton Graubünden [51]. In the study of Bonetti et al. [52] in order to rule out a general trend towards a decrease in the incidence of AMI in Switzerland, the authors investigated the number of patients who were hospitalised with a diagnosis of AMI in the canton Lucerne, a Swiss area without smoke-free legislation. In the same period while in canton Graubünden a smoking ban was already active, an increase in the incidence of AMI was found in canton Lucerne. In Italy, a reduction of cigarette sales and a significant increase in nicotine replacement therapy sales were reported after the enforcement of a smoking ban [46]. In Switzerland, these data were unfortunately not available but a simultaneously obtained public questionnaire revealed that people living in regions with smoking bans have less exposure to SHS, and 21% of the participants reported a reduction in their cigarette consumption after the enforcement of the smoking ban [53].

Conclusions

Since Christopher Columbus carried the tobacco from the New World to Europe many things have changed. Epidemiological data collected since 1980 unequivocally prove the relationship between passive smoking and heart disease and second-hand smoke has been recognised to cause an increased risk of acute myocardial infarction by 25% to 31%. Smoking bans in public places and workplaces are significantly associated with a reduction in acute myocardial infarction incidence, particularly if enforced over several years. Globally community smoking bans account for a 17% reduction in AMI incidence. If this association represents a cause-and-effect relationship, and assuming approximately 920,000 incident AMIs each year in the USA, a nationwide ban on public smoking might ultimately prevent as many as 156,400 new AMIs yearly [12]. We are not aware of any drug or instrumental intervention that can reduce the incidence of acute myocardial infarction. This proves how control of population-based risk is at least as important as control of individual risk.

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