

# Is there benefit in smoking cessation prior to cardiac surgery?

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Received 8 January 2012; received in revised form 16 March 2012; accepted 1 April 2012

## Abstract

A best evidence topic was written according to a structured protocol. The question addressed was whether smoking cessation prior to cardiac surgery would result in a greater freedom from postoperative complications. A total of 564 papers were found using the reported searches, of which five represented the best evidence to answer the clinical question. The authors, date, journal, study type, population, main outcome measures and results are tabulated. Reported measures were operative mortality, pulmonary complications, infective complications, neurological complications, transfusion requirements, duration of ventilation, intensive care unit and hospital stay, intensive care unit re-admission, postoperative gas exchange parameters and postoperative pulmonary function. The largest of the best evidence studies demonstrated a significant reduction in pulmonary complications in non-smokers ( $P < 0.001$ ); however, there was an increased requirement for transfusion in this cohort ( $P = 0.002$ ). There were non-significant reductions in neurological complications, infective complications and re-admissions to intensive care. Another large cohort study demonstrated significant reductions in mortality ( $P < 0.0001$ ), pulmonary complications ( $P = 0.0002$ ), infection ( $P < 0.0007$ ), intensive care unit re-admission ( $P = 0.0002$ ), duration of mechanical ventilation ( $P = 0.026$ ) and intensive care unit stay ( $P = 0.002$ ). A larger cohort study again demonstrated significant reductions in non-smokers in pulmonary complications ( $P < 0.002$ ), duration of mechanical ventilation ( $P < 0.012$ ) and intensive care unit stay ( $P < 0.005$ ). A smaller prospective cohort study reported significantly raised PaO<sub>2</sub> ( $P = 0.0091$ ) and reduced PaCO<sub>2</sub> ( $P < 0.0001$ ) levels in the non-smokers as well as improved FVC and FEV<sub>1</sub> ( $P < 0.0001$ ). There were also reductions in duration of intubation ( $P < 0.0001$ ), intensive care unit stay ( $P < 0.0001$ ) and hospital stay ( $P < 0.0013$ ). Another small cohort study reporting outcomes of heart transplantation demonstrated significant improvement in non-smokers in terms of survival ( $P = 0.031$ ), duration of intubation ( $P = 0.05$ ) and intensive care unit stay ( $P = 0.021$ ). We conclude that there is strong evidence demonstrating superior outcomes in non-smokers following cardiac surgery and advocate the necessity of smoking cessation as soon as possible prior to cardiac surgery.

**Keywords:** Smoking • Smoking cessation • Cardiac surgery

## INTRODUCTION

A best evidence topic was constructed according to a structured protocol. This protocol is fully described in ICVTS [1].

## CLINICAL SCENARIO

An asymptomatic 67-year-old man with a significant three-vessel disease on coronary angiography is referred for consideration of a coronary artery bypass surgery (CABG). He has been a life-long smoker with a 20-pack-year smoking history. However, his pulmonary function tests are within acceptable limits. He has no other respiratory comorbidities. You advise him regarding smoking cessation and consider whether to delay his operation until he has quit smoking.

## THREE-PART QUESTION

In [patients undergoing elective cardiac surgery] does [smoking cessation preoperatively] result in [greater freedom from post operative complications]?

## SEARCH STRATEGY

Medline from 1948 to December 2011 using the PubMed interface ('smoking cessation' [MeSH Terms] OR ('smoking' AND 'cessation') OR ('smoking cessation') AND ('thoracic surgery') [MeSH Terms] OR ('thoracic' AND 'surgery') OR ('thoracic surgery') OR ('cardiac' AND 'surgery') OR ('cardiac surgery') OR ('cardiac surgical procedures') [MeSH Terms] OR ('cardiac' AND 'surgical' AND 'procedures') OR ('cardiac surgical procedures') OR ('cardiac' AND 'surgery'). Related articles and references were screened for suitable articles.

**Table 1:** Best evidence papers

Author, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
Al-Sarraf <i>et al.</i> (2008) Ann Thorac Surg, UK  Retrospective cohort study (level 3 evidence) [2]	2587 consecutive patients undergoing isolated CABG between 2000 and 2007	Operative mortality	Current smokers: 14 (2.9%); OR 0.84 (0.44–1.63) Former smokers: 29 (2.1%); OR 0.60 (0.35–1.03) Non-smokers: 26 (3.5%); OR 1.0 (–) P = 0.168	Smoking is associated with significant pulmonary complications after CABG. In-hospital mortality is not influenced by smoking. Smokers should be encouraged to quit before undergoing CABG, and a period of 1 month may be beneficial, given that former smokers in this study seem to have better prognosis than current smokers
	All operations performed through median sternotomy and use of CPB	Re-exploration	Current smokers: 23 (4.8); OR 1.07 (0.62–1.84) Former smokers: 66 (4.8); OR 1.07 (0.70–1.63) Non-smokers: 34 (4.5%); OR 1.0 (–) P = 0.950	
	Patients stratified into three groups: Current smokers (n = 473) Former smokers (n = 1346) (cessation >4 weeks pre-op) Non-smokers (n = 748)	IABP and inotropic support required	Current smokers: 30 (6.3%); OR 1.02 (0.63–1.66) Former smokers: 64 (4.7%); OR 0.78 (0.52–1.16) Non-smokers: 44 (5.9%); OR 1.0 (–) P = 0.354	
		Ventilation >24 h	Current smokers: 22 (4.6%); OR 0.96 (0.56–1.65) Former smokers: 62 (4.5%); OR 0.94 (0.62–1.43) Non-smokers: 36 (4.8%); OR 1.0 (–) P = 0.962	
		Pulmonary complications	Current smokers: 143 (30.1%); OR 1.73 (1.33–2.26) Former smokers: 318 (23.3%); OR 1.22 (0.98–1.52) Non-smokers: 149 (19.9%); OR 1.0 (–) P < 0.001	
	Neurological complications	Current smokers: 34 (7.2%); OR 1.40 (0.88–2.25) Former smokers: 83 (6.1%); OR 1.18 (0.80–1.74) Non-smokers: 39 (5.2%); OR 1.0 (–) P = 0.377		
	Infective complications	Current smokers: 45 (9.5%); OR 1.27 (0.84–1.91) Former smokers: 122 (8.9%); OR 1.19 (0.86–1.65) Non-smokers: 57 (7.6%); OR 1.0 (–) P = 0.459		
	Renal complications (requirement for dialysis)	Current smokers: 9 (1.9%); OR 0.89 (0.55–1.44) Former smokers: 34 (2.5%); OR 1.13 (0.79–1.61) Non-smokers: 23 (3.1%); OR 1.0 (–) P = 0.417		
	Gastrointestinal complications	Current smokers: 18 (3.8%); OR 1.69 (0.86–3.32) Former smokers: 50 (3.7%); OR 1.64 (0.94–2.86) Non-smokers: 17 (2.3%); OR 1.0 (–) P = 0.181		

Continued

Table 1: (Continued)

Author, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
		Readmission to ICU	Current smokers: 19 (4.0%); OR 1.91 (0.97–3.75) Former smokers: 43 (3.2%); OR 1.49 (0.83–2.66) Non-smokers: 16 (2.1%); OR 1.0 (-) P = 0.163	
		Mean ICU stay (days)	Current smokers: 1.8 ± 3.2 Former smokers: 2.0 ± 4.6 Non-smokers: 2.3 ± 5.0 P = 0.144	
		Mean postoperative stay (days)	Current smokers: 8.9 ± 10.5 Former smokers: 9.2 ± 11.9 Non-smokers: 9.9 ± 16.5 P = 0.078	
		Blood transfusion	Current smokers: 166 (34.9%); OR 0.68 (0.54–0.86) Former smokers: 511 (37.5%); OR 0.76 (0.63–0.91) Non-smokers: 330 (44.1%); OR 1.0 (-) P = 0.002	
Jones <i>et al.</i> (2011) Interact CardioVasc Thorac Surg, UK [3]	1108 patients undergoing cardiac surgery between 2002 and 2007	Overall population: Operative mortality	Current smokers: 24 (4.3%) Never smokers: 13 (2.3%) P = 0.067	The current data strengthen the observation that preoperative smoking is predictive of adverse outcomes of cardiac surgery in the elderly, and pulmonary complications may exert a significant effect on outcome
Retrospective cohort study (level 3 evidence)	CABG: 63.4% Valve: 23.1% CABG + valve: 10.1% Other procedures: 3.4%	Pulmonary complication	Current smokers: 60 (11.0%) Never smokers: 37 (6.8%) P = 0.01	
	Patients stratified into two groups: Current smokers (n = 554) Never smokers (n = 554)	ICU re-admission	Current smokers: 38 (6.9%) Never smokers: 22 (4.0%) P = 0.03	
	The two groups were sub-stratified Current smokers: ≤70 years (n = 473) >70 years (n = 81) Never smokers: ≤70 years (n = 360) >70 years (n = 194)	Infection	Current smokers: 176 (31.8%) Never smokers: 122 (22.0%) P < 0.001	
		New renal replacement	Current smokers: 31 (5.6%) Never smokers: 23 (4.2%) P = NS	
		Blood transfusion	Current smokers: 336 (60.1%) Never smokers: 360 (65.1%) P = NS	
		Re-exploration	Current smokers: 30 (5.4%) Never smokers: 35 (6.3%) P = NS	
		Stroke	Current smokers: 13 (2.4%) Never smokers: 6 (1.1%) P = NS	
		Mean ventilation, h (range)	Current smokers: 8.9 (0–640) Never smokers: 8.2 (0–46) P = NS	

Continued

Table 1: (Continued)

Author, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
		Mean ICU stay, days (range)	Current smokers: 3.6 (0–60) Never smokers: 2.5 (0–75) P = NS	
		>70 years cohort: Operative mortality	Current smokers: 12 (14.8%) Never smokers: 4 (2.1%) P < 0.0001	
		Pulmonary complication	Current smokers: 20 (24.7%) Never smokers: 16 (8.2%) P = 0.0002	
		ICU re-admission	Current smokers: 16 (19.8%) Never smokers: 10 (5.2%) P = 0.0002	
		Infection	Current smokers: 36 (44.4%) Never smokers: 46 (23.8%) P < 0.0007	
		New renal replacement	Current smokers: 14 (17.3%) Never smokers: 6 (3.1%) P < 0.0001	
		Blood transfusion	Current smokers: 57 (70.4%) Never smokers: 139 (71.6%) P = NS	
		Re-exploration	Current smokers: 4 (4.9%) Never smokers: 14 (7.2%) P = NS	
		Stroke	Current smokers: 4 (4.9%) Never smokers: 5 (2.6%) P = NS	
		Mean ventilation (h) (range)	Current smokers: 76.1 (0–22) Never smokers: 37.5 (0–46) P = 0.026	
		Mean ICU stay, days (range)	Current smokers: 6.2 (1–60) Never smokers: 2.8 (0–66) P = 0.002	
Ngaage <i>et al.</i> (2002) Cardiovasc Surg, UK [4]	2163 patients undergoing elective cardiac surgery between 1993 and 1999	Operative mortality	Smokers: 4.2% Ex-smokers: 3.2% Non-smokers: 2.8%	Active smokers have a comparatively poor postoperative respiratory outcome after cardiac surgery.
Retrospective cohort study (level 3 evidence)	CABG: 1579 (73%) Valve: 372 (17.2%) CABG + valve: 212 (9.8%)	Mean ICU stay (h)	Smokers: 60 Ex-smokers: 34 Non-smokers: 31 P < 0.005	The duration of mechanical ventilation has a direct impact on the risk of postoperative pulmonary complications
	Patients stratified into three groups: Smokers (n = 207) Ex-smokers (n = 1075) (cessation >3 months pre-op) Non-smokers (n = 881)	Postoperative pulmonary complications:	Smokers: 29.5% Ex-smokers: 14.7% Non-smokers: 13.6% P < 0.002	
		Atelectasis	Smokers: 10.6% Ex-smokers: 5.2% Non-smokers: 4.8%	
		Chest infection	Smokers: 7.2% Ex-smokers: 1.9% Non-smokers: 2.1%	

Table 1: (Continued)

Author, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
		Pleural effusion	Smokers: 3.9% Ex-smokers: 4% Non-smokers: 3.9%	
		ARDS	Smokers: 3.4% Ex-smokers: 1.3% Non-smokers: 1.4%	
		Mean duration of mechanical ventilation, h	Smokers: 16 Ex-smokers: 7.9 Non-smokers: 8.3 $P < 0.012$	
		Sternal wound infection	Smokers: 15% Ex-smokers: 11% Non-smokers: 15%	
		Mediastinitis	Smokers: 2.4% Ex-smokers: 1.4% Non-smokers: 1%	
Arabaci <i>et al.</i> (2003) Jpn Heart J, Turkey [5]	213 consecutive patients undergoing elective isolated CABG	Postoperative arterial blood gas analysis: PaO <sub>2</sub> (mmHg)	Smokers: 66.1 ± 8.0 Non-smokers: 69.1 ± 8.9 $P = 0.0091$	Preoperative evaluation of the pulmonary status of patients with a history of smoking who are scheduled for elective revascularization surgery is important, and that smoking cessation should be strongly encouraged performed preoperatively as early as possible in order to minimize postoperative respiratory complications
Prospective cohort study (level 3 evidence)	All operations performed through median sternotomy and use of CPB	PaCO <sub>2</sub> (mmHg)	Smokers: 38.6 ± 3.6 Non-smokers: 32.0 ± 4.7 $P < 0.0001$	
	Patients stratified into two groups: Smokers ( $n = 117$ ) Non-smokers ( $n = 96$ ) (cessation >20 years pre-op)	pH	Smokers: 7.4 ± 0.1 Non-smokers: 7.4 ± 0.1 $P = NS$	
		Postoperative pulmonary function tests: VC (L)	Smokers: 2.3 ± 0.4 Non-smokers: 2.7 ± 0.4 $P < 0.0001$	
		FVC (L)	Smokers: 2.4 ± 0.5 Non-smokers: 2.8 ± 0.4 $P < 0.0001$	
		FEV <sub>1</sub> (L)	Smokers: 1.7 ± 0.4 Non-smokers: 2.1 ± 0.2 $P < 0.0001$	
		FEV <sub>1</sub> /FVC	Smokers: 72.2 ± 11.5 Non-smokers: 76.0 ± 9.8 $P = 0.0110$	
		Intubation period (h)	Smokers: 19.9 ± 11.5 Non-smokers: 14.1 ± 4.3 $P < 0.0001$	
		ICU stay (days)	Smokers: 3.2 ± 1.3 Non-smokers: 2.4 ± 0.6 $P < 0.0001$	
		Hospitalization period (days)	Smokers: 14.1 ± 4.4 Non-smokers: 12.5 ± 2.4 $P < 0.0013$	
		Pulmonary complications: Atelectasis	Smokers: 5 (4.3%) Non-smokers: 2 (2.1%)	
		Pleural effusion		

Continued

Table 1: (Continued)

Author, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
			Smokers: 11 (9.4%) Non-smokers: 4 (4.2%)	
		Chest infection	Smokers: 8 (6.8%) Non-smokers: 4 (4.2%)	
		Total	Smokers: 24 (20.5%) Non-smokers: 10 (10.4%)	
Sanchez-Lazaro <i>et al.</i> (2007) Transplant Proc, Spain [6]	288 patients undergoing heart transplantation between 1987 and 2006	Survival rate	Smokers: 81.63% Ex-smokers: 92.11% Non-smokers: 89.57% $P = 0.031$	Patients who smoke or have smoked until shortly before heart transplantation show a poorer prognosis and a higher rate of early pulmonary complications after heart transplantation
Retrospective cohort study (level 3 evidence)	Patients stratified into three groups: Smokers ( $n = 49$ ) Ex-smokers ( $n = 76$ ) (cessation < 1 year pre-op) Non-smokers ( $n = 163$ ) (cessation > 1 year pre-op)	Mean intubation time, h	Smokers: $14.2 \pm 7.3$ Ex-smokers: $33.4 \pm 44.6$ Non-smokers: $17.9 \pm 19.2$ $P = 0.05$	The deleterious effects of smoking are progressively reduced as the interval between smoking cessation and transplantation increases
		Mean ICU stay, days	Smokers: $4.4 \pm 1.88$ Ex-smokers: $7.9 \pm 10.5$ Non-smokers: $4.84 \pm 3.49$ $P = 0.021$	

## SEARCH OUTCOME

Five hundred and sixty-four articles were found using the reported search strategy. From these, five articles were identified that provided the best evidence to answer the question. These are presented in Table 1.

## RESULTS

Al-Sarraf *et al.* [2] conducted a retrospective cohort study of 2587 consecutive patients undergoing isolated CABG. The patients were stratified into three groups of current smokers ( $n = 473$ ); former smokers, having stopped >4 weeks pre operatively ( $n = 1346$ ); and non-smokers ( $n = 748$ ). Significant reductions in pulmonary complications were observed between the groups, with incidences of 30.1, 23.3 and 19.9% in the current smokers, former smokers and non-smokers, respectively ( $P < 0.001$ ). An inverse relationship in blood transfusion requirements was observed, with incidences of 34.9, 37.5 and 44.1% in the current smokers, former smokers and non-smokers, respectively ( $P = 0.002$ ). Statistically non-significant reductions were observed in neurological complications (7.2, 6.1 and 5.2%, respectively,  $P = 0.377$ ), infective complications (9.5, 8.9 and 7.6%, respectively,  $P = 0.459$ ) and re-admissions to the intensive care unit (4.0, 3.2 and 2.1%, respectively,  $P = 0.163$ ).

Jones *et al.* [3] conducted a retrospective cohort study of 1108 patients undergoing cardiac surgery, stratified into two groups, current smokers ( $n = 554$ ) and never smokers ( $n = 554$ ). A further subgroup analysis was carried out on patients above and below 70 years of age. There was a non-significant reduction in operative mortality in the never smokers (2.3 vs 4.3%,  $P = 0.067$ ). There were

significant reductions in the never smokers in terms of pulmonary complications (6.8 vs 11%,  $P = 0.01$ ), intensive care unit re-admission (4.0 vs 6.9%,  $P = 0.03$ ) and infection (22.0 vs 31.8%,  $P < 0.001$ ). In the subgroup analysis of the >70-year old patients, there were significant reductions in the never smokers in terms of operative mortality (2.1 vs 14.8%,  $P < 0.0001$ ), pulmonary complications (8.2 vs 24.7%,  $P = 0.0002$ ), intensive care unit re-admission (5.2 vs 19.8%,  $P = 0.0002$ ), infection (23.8 vs 44.4%,  $P < 0.0007$ ), new renal replacement (3.1 vs 17.3%,  $P < 0.0001$ ), mean mechanical ventilation hours (37.5 vs 76.1,  $P = 0.026$ ) and mean intensive care unit days (2.8 vs 6.2,  $P = 0.002$ ).

Ngaage *et al.* [4] conducted a retrospective cohort study of 2163 patients undergoing elective cardiac surgery, stratified into three groups: smokers ( $n = 207$ ), ex-smokers ( $n = 1075$ ) and non-smokers ( $n = 881$ ). Significant reductions in favour of the non-smoking groups were observed in terms of mean intensive care unit hours (60, 34 and 31 in the smokers, ex-smokers and non-smokers, respectively,  $P < 0.005$ ), pulmonary complications (29.5, 14.7 and 13.6%, respectively,  $P < 0.002$ ) and mean mechanical ventilation hours (16, 7.9 and 8.3, respectively,  $P < 0.012$ ).

Arabaci *et al.* [5] conducted a prospective cohort study of 213 consecutive patients undergoing elective isolated CABG. Patients were stratified into two groups: smokers ( $n = 117$ ) and non-smokers, having stopped >20 years preoperatively ( $n = 96$ ). Postoperative arterial blood gas analysis demonstrated significantly superior results for the non-smokers in PaO<sub>2</sub> (mmHg) (69.1 vs 66.1,  $P = 0.0091$ ) and PaCO<sub>2</sub> (mmHg) (32.0 vs 38.6,  $P < 0.0001$ ). Postoperative pulmonary function tests demonstrated significant increases in the non-smokers in vital capacity (VC, L) (2.7 vs 2.3,  $P < 0.0001$ ), forced vital capacity (FVC, L) (2.8 vs 2.4,  $P < 0.0001$ ), forced expiratory volume (FEV<sub>1</sub>, L) (2.1 vs 1.7,  $P < 0.0001$ ) and FEV<sub>1</sub>/FVC ratio (76.0 vs 72.2,  $P = 0.0110$ ). There

were also significant reductions in intubation hours (14.1 vs 19.9,  $P < 0.0001$ ), intensive care unit days (2.4 vs 3.2,  $P < 0.0001$ ) and hospitalization days (12.5 vs 14.1,  $P < 0.0013$ ) in favour of the non-smokers.

Sanchez-Lazaro *et al.* [6] conducted a retrospective cohort study of 288 patients undergoing heart transplantation, who were stratified into three groups: smokers ( $n = 49$ ), ex-smokers, having stopped  $< 1$  year preoperatively ( $n = 76$ ), and non-smokers, having stopped  $> 1$  year preoperatively ( $n = 163$ ). Significant improvement in survival was observed in the non-smoking groups with the rates of 81.63, 92.11 and 89.57% in the smokers, ex-smokers and non-smokers, respectively ( $P = 0.031$ ). Similar improvements were observed in terms of mean intubation hours (14.2, 33.4 and 17.9, respectively,  $P = 0.05$ ) and mean intensive care unit days (4.4, 7.9 and 4.84, respectively,  $P = 0.021$ ).

## CLINICAL BOTTOM LINE

There is convincing evidence presented that patients who are not active smokers at the time of cardiac surgery have improved outcomes postoperatively in comparison with smokers. This is evident in terms of a reduction in mortality, pulmonary complications, infective complications, duration of mechanical ventilation, intensive care unit stay and re-admission and overall hospital stay. There are also improvements observed in post operative gas exchange and pulmonary function. There is a great

variation observed in the duration of smoking cessation required to achieve these outcomes; however, it is widely accepted that the longer the duration preoperatively, the greater the benefit to the patient. These findings support the necessity of smoking cessation as soon as possible prior to cardiac surgery.

**Conflict of interest:** none declared.

## REFERENCES

- [1] Dunning J, Prendergast B, Mackway-Jones K. Towards evidence-based medicine in cardiothoracic surgery: best BETS. *Interact CardioVasc Thorac Surg* 2003;2:405-9.
- [2] Al-Sarraf N, Thalib L, Hughes A, Tolan M, Young V, McGovern E. Effect of smoking on short-term outcome of patients undergoing coronary artery bypass surgery. *Ann Thorac Surg* 2008;86:517.
- [3] Jones R, Nyawo B, Jamieson S, Clark S. Current smoking predicts increased operative mortality and morbidity after cardiac surgery in the elderly. *Interact Cardiovasc Thorac Surg* 2011;12:449.
- [4] Ngaage DL, Martins E, Orkell E, Griffin S, Cale AR, Cowen ME *et al.* The impact of the duration of mechanical ventilation on the respiratory outcome in smokers undergoing cardiac surgery. *Cardiovasc Surg* 2002; 10:345.
- [5] Arabaci U, Akdur H, Yigit Z. Effects of smoking on pulmonary functions and arterial blood gases following coronary artery surgery in Turkish patients. *Jpn Heart J* 2003;44:61.
- [6] Sanchez-Lazaro IJ, Almenar L, Martinez-Dolz L, Moro J, Ortiz-Martinez V, Izquierdo MT *et al.* Impact of smoking on survival after heart transplantation. *Transplant Proc* 2007;39:2377.