Body pain - an unheeded personal health hazard in interventional cardiologists: A national online cross-sectional survey study in China

Ru-Hong Jiang[1], Meng-meng Chen[1], QIANG LIU[1], Guo-sheng Fu[1], yumei xue[2], Hua Fu[3], Shulin Wu[4], Chang Sheng Ma[5], Deyong Long[5], and Chen-Yang Jiang[1]

[1]Zhejiang University School of Medicine Sir Run Run Shaw Hospital
[2]Guangdong Provincial People's Hospital, Guangdong Academy of Medical Sciences
[3]Sichuan University West China Hospital Department of Cardiology
[4]Guangdong Cardiovascular Institute, Guangdong General Hospital,
[5]Beijing Anzhen Hospital, Capital Medical University

April 05, 2024

Abstract

Introduction: Interventional cardiology procedures (ICPs) have become the mainstay treatments in cardiology diseases and increased rapidly. This study aims to assess the occupational health hazards (OHHs) related to the long-time wearing of lead personal protective equipment and reveal health protection needs in interventional cardiologists. Methods and Results: We invited interventional and non-interventional cardiologists in tertiary III hospitals in China to participate in an online cross-sectional survey on their health status, utilization of personal protective equipment (PPE), and personal health protection (PHP) needs. Propensity score methods were used for comparisons of OHHs between the matched interventional and non-interventional cardiologists. Totally, 642 interventional and 402 non-interventional cardiologists completed the survey. The interventional cardiologists had significantly higher incidence of body pain (56.6% vs. 24.2%, p<0.001), bone and joint disease (21.7% vs. 8.6%, p=0.001), cataract (3.5% vs. 0%, p=0.039), and anxiety (8.1% vs. 2.5%, p=0.029) than the matched non-interventional cardiologists. The risk of back pain was independently associated with female gender, performing percutaneous coronary intervention procedure or [?]2 types of ICP, and the personal annual volume of ICPs. Only 3.3% of interventional cardiologists were satisfied with PPE and 83.0% of them complained of physical toll caused by heavy PPE. 90.7% were willing to conduct ICP without radiation exposure. Conclusions: Body pain was the main OHH in interventional cardiologists likely due to wearing heavy lead PPE for long working hours. Besides training more interventional cardiologists, the adoption of emerging technologies without heavy lead PPE will be a promising way to reduce the OHH burden.

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Ruhong Jiang, MD[a], Mengmeng Chen, MD[a], Qiang Liu, MS[a], Guosheng Fu, MD[a], Yumei Xue, MD[b], Hua Fu, MD[c], Shulin Wu, MD[b], Changsheng Ma, MD[d], Deyong Long, MD[d], Chenyang Jiang, MD[a]

[a] *Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University, Hangzhou, China.*

[b] *Guangdong Provincial People's Hospital, Guangdong Academy of Medical Sciences, Guangzhou, China.*

[c] *Department of Cardiology, West China Hospital, Sichuan University, Chengdu, China.*

[d] *Beijing Anzhen Hospital, Capital Medical University, Beijing 100029, China.*

Dr. Ruhong Jiang and Dr. Mengmeng Chen contributed equally.

Acknowledgments: None

Funding sources: None

Dsiclosures: None

Running title: Body pain in interventional cardiologists

Word Count: 4366

Corresponding Authors:

Chenyang Jiang, M.D.

Department of Cardiology, Sir Run Run Shaw Hospital

Zhejiang University School of Medicine

3 East Qingchun Road

Hangzhou, Zhejiang, 310016, P.R. China.

Fax: 0086-0571-86945874 | Telephone: 0086-13857190051

E-mail: *cyjiang@zju.edu.cn*

ABSTRACT

Introduction: Interventional cardiology procedures (ICPs) have become the mainstay treatments in cardiology diseases and increased rapidly. This study aims to assess the occupational health hazards (OHHs) related to the long-time wearing of lead personal protective equipment and reveal health protection needs in interventional cardiologists.

Methods and Results: We invited interventional and non-interventional cardiologists in tertiary III hospitals in China to participate in an online cross-sectional survey on their health status, utilization of personal protective equipment (PPE), and personal health protection (PHP) needs. Propensity score methods were used for comparisons of OHHs between the matched interventional and non-interventional cardiologists. Totally, 642 interventional and 402 non-interventional cardiologists completed the survey. The interventional cardiologists had significantly higher incidence of body pain (56.6% vs. 24.2%, p<0.001), bone and joint disease (21.7% vs. 8.6%, p=0.001), cataract (3.5% vs. 0%, p=0.039), and anxiety (8.1% vs. 2.5%, p=0.029) than the matched non-interventional cardiologists. The risk of back pain was independently associated with female gender, performing percutaneous coronary intervention procedure or [?]2 types of ICP, and the personal annual volume of ICPs. Only 3.3% of interventional cardiologists were satisfied with PPE and 83.0% of them complained of physical toll caused by heavy PPE. 90.7% were willing to conduct ICP without radiation exposure.

Conclusions: Body pain was the main OHH in interventional cardiologists likely due to wearing heavy lead PPE for long working hours. Besides training more interventional cardiologists, the adoption of emerging technologies without heavy lead PPE will be a promising way to reduce the OHH burden.

Key Words : Interventional cardiologists, occupational health hazard, back pain, personal protection equipment, health protection needs.

Introduction

Interventional cardiology procedures (ICPs) such as percutaneous coronary intervention (PCI) and radiofrequency catheter ablation have become mainstay treatments to improve clinical outcomes in patients with coronary artery disease (CAD)[1, 2] and cardiac arrhythmias[3, 4]. Current ICP routinely requires x-ray guidance. The occupational health hazards (OHHs) associated with x-ray radiation exposure in interventional

cardiologists have been well-recognized[5]. Wearing of lead personal protective equipment (PPE) is warranted to minimize the harm caused by radiation exposure. However, long-time wearing of heavy lead PPE produces subsequent OHH that is usually ignored: body pain. Previous research has reported the correlation between wearing lead aprons and spine problems[6, 7]. A survey of interventional cardiologists in the United States showed that nearly half of the participants suffered chronic back pain and one-fourth had problems related to their hips, knees, or ankles[8].

It is estimated that over 1 million ICPs are conducted annually by about 5,000 interventional cardiologists in 2,000 tertiary cardiac care facilities in China[9]. PCI is one of the major types of ICPs, with annual volume increased by 21 times from 2001 to 2011 in China[2]. Another major type of ICPs is cardiac arrhythmia catheter ablation, which increased by 1.7 times from 2009 to 2016[10]. Atrial fibrillation (AF) is the most common arrythmia, with $>$ 10 million patients in China[11]. However, the proportion of patients with AF that received ablation therapy in China was only 1.22%, much lower than that in developed countries (about 5% in the United States[12] and 28.2% in Japan[13]). Predictably, the volume of AF ablation procedure will increase dramatically due to high level of recommendation for catheter ablation[14]. The burgeoning need for ICPs demands interventional cardiologists in China to work harder, which puts them at a higher risk of OHHs.

To explore their OHHs and the unmet health protection needs, the Chinese Society of Cardiology (CSC) and Chinese Heart Rhythm Society (CHRS) endorsed this national online survey in the registered interventional cardiologists.

Methods

This cross-sectional study implemented by the Youth Commission of both CSC and CHRS was approved by the Institutional Review Board (IRB) of Sir Run Run Shaw Hospital.

Participants

All cardiologists working in tertiary hospitals were eligible for this study.

Data collection

A quick response (QR) code was created to facilitate the process of recruiting cardiologists in the survey. The QR code was initially released at the 20$^{\text{th}}$ CHRS scientific sessions in August 2020 and circulated via several social media platforms targeting cardiologists in the following 4 months. After scanning the QR code, participants would be guided to the survey website for eligibility assessment. The questionnaire would launch after the participant providing informed consent.

Questionnaire design

The questionnaire consisted of questions on demographics, occupation, lifestyle, the ICP workload, utilization of PPE, OHH, and PHP needs of interventional cardiologists. OHHs were assessed with respect to orthopedic pain and comorbidities. A detailed assessment of pain location, pain severity, pain management, and pain-related sick leave was conducted. The verbal pain rating scale[15] was used to assess pain severity. This questionnaire also included questions of satisfaction with the current PPE used in ICPs, limitations associated with PPE, concerns of career development and PHP needs. Non-interventional cardiologists were guided only to questions on demographics, occupation, lifestyle and OHH.

Data analysis

Participants were divided into the interventional cardiologist group (ICG) and the non-interventional cardiologist group (non-ICG). ICG and non-ICG were matched by propensity score using information collected on demographics, occupation, and lifestyle. The greedy approach was used to identify the best propensity score-matched pairs based on propensity score difference $<$ 0.001 between the paired patients. OHHs in the two propensity-score matched groups were compared using paired t-test or McNemar test according to the nature and distribution of the measured outcomes. The data collected on ICP, PPE, radiation exposure and

PHP needs in interventional cardiologists were summarized using descriptive statistical methods. Univariate and multiple logistic regression analyses were conducted to identify predictors for back pain in interventional cardiologists. All data analyses were conducted using the statistical software R (4.0)[16]. The statistical significance was defined as a two-sided p-value < 0.05.

Results

A total of 1,340 surveys were submitted during the collection period. After removing 296 surveys that did not meet the eligibility criteria, the final data analyses were based on surveys completed by 642 interventional cardiologists and 402 non-interventional cardiologists from 179 cities across China. The flow diagram for survey participants is illustrated in Figure 1.

Demographics, occupational information, ICP workload, utilization of PPE of interventional cardiologists

The ICG included 642 interventional cardiologists who were characterized by relatively young age (39.9+/-6.7 years), high male proportion (75.9%), normal BMI (23.4+/-2.8 kg/m^2), and healthy lifestyle (current smoking rate: 7.6%; regular drinking rate: 1.1%). Most of these cardiologists have a master's or doctoral degree (77.4%) and > half (55.8%) have a title of associate chief physician or chief physician. Most interventional cardiologists work in general hospitals (94.5%), hospitals of the highest rank (tier IIIA) (79.8%), and in tier I or II cities (66.4%) in China. They had an average of 8.8 years of occupational experience of ICPs and conducted an average of 340.2 ICPs per year. The average time spent on ICPs was 3.1 days per week and 5.0 hours per day. The average time with wearing lead PPE was 4.2 hours per day. The most common utilized PPEs include lead clothes (99.4%), lead collars (94.7%), lead apron (60.1%) and personal radiation dose counter (52.8%). The reported data above is summarized in Table 1.

Comparisons of propensity-score matched ICG and non-ICG for OHH-related outcomes

A total of 198 propensity-score matched pairs were successfully identified between the ICG and non-ICG. The data collected on demographics, occupation, and lifestyle were compared to balance between the matched ICG and non-ICG (Table 2). The matched ICG was associated with doubled incidence of body pain when compared to the matched non-ICG (56.6% vs. 24.2%, p<0.001). The comparisons showed that cardiologists in ICG had significantly higher incidence of neck pain (29.8% vs. 11.6%, p<0.001), shoulder pain (33.3% vs. 14.1%, p<0.001), back pain (45.5% vs. 14.1%, p<0.001), buttock pain (4.0% vs. 0.5%, p<0.046), knee pain (17.7% vs. 3.0%, p<0.001), thigh pain (7.6% vs. 1.0%, p=0.004), calf pain (10.6% vs. 1.0%, p<0.001), ankle pain (8.1% vs. 2.0%, p=0.010) and foot pain (5.1% vs. 0.0%, p=0.031). No significant differences were identified for the verbal pain rating scale, the incidence of severe pain, pain treatment rate and sick leave days due to pain in the last five years. Interventional cardiologists had higher incidence of at least one comorbidity (36.4% vs. 11.2%, p<0.001) and specific comorbidities including bone and joint diseases (21.7% vs. 8.6%, p<0.001), cataract (3.5% vs. 0.0%, p=0.039) and anxiety (8.1% vs. 2.5%, p=0.029). The OHH-related outcomes are summarized in Table 3.

Predictors for back pain in the interventional cardiologists

Multiple logistic regression analyses identified that female gender [relative to male: odds ratio (OR) 2.353, 95% CI 1.485 to 3.777, p<0.001], the type of ICPs (relative to conducting arrhythmia catheter ablation: OR for PCI 2.088, 95% CI 1.106 to 3.995, p=0.024; OR for conducting two or more ICP 1.779, 95% CI 1.008 to 3.177, p=0.048), personal annual volume of ICPs (relative to 100 cases or less: OR for 101 to 300 cases 1.659, 95% CI 1.059 to 2.614, p=0.028; OR for 301 to 500 cases 2.182, 95%CI 1.296 to 3.705, p=0.004; OR for > 500 cases 3.302, 95%CI 1.816 to 6.112, p<0.001) were associated with the occurrence of back pain. The results of the multiple logistic regression analyses are illustrated in Figure 2.

Assessments for the satisfaction of PPE and PHP needs in interventional cardiologists

Based on survey results, only 3.3% of interventional cardiologists were fully satisfied with the PPE; and only 3.9% reported no negative health impact of PPE; 83.0% reported complaints about the physical toll of wearing heavy PPE; 74.0% reported concerns about the protective efficacy of PPE from radiation exposure, and

91.0% reported lingering concerns about radiation exposure even with the utilization of PPE. Additionally, 39.1% of interventional cardiologists considered quitting their ICP career due to reasons such as health risks associated with radiation exposure (85.7%), poor quality of life and stress (69.7%), and concerns from family members (55.4%). Finally, 90.7% of them expressed their wish for future ICPs without radiation exposure and wearing PPE. Responses to survey questions on the level of satisfaction are summarized in online table 1.

Discussion

To our knowledge, this is the first national survey-based study designed to assess the OHHs in interventional cardiologists in China. With an appropriate control (i.e., non-interventional cardiologists) and propensity score methods, this study revealed that interventional cardiologists in China experience significantly higher incidence of body pain, mainly of the back. Long working hours may play an important role in the development of body pain. Even with relatively short occupational experience of ICPs (average 8.8 years), other OHHs, such as bone and joint diseases, cataract, and anxiety, were found significantly more common in interventional cardiologists in China.

The last two decades have witnessed a rapid growth in number of interventional cardiologists in tertiary hospitals in China. They are relatively younger and have relatively shorter ICP working years than their colleagues in the developed countries. The reported median age of interventional cardiologists in the United States was 48 years[17], approximately 10 years older than the median age of Chinese counterparts surveyed in this study. However, the large patient population and the relative shortage of well-trained colleagues have led to an overwhelming workload. The surveyed interventional cardiologists conducted > 340 ICPs per year on average, which is a much higher personal volume than that reported previously (200 per year in Europe[18] and 268 per year[19] in the United States). The high annual personal volume may explain the comparable prevalence of body pain in relative younger interventional cardiologists in China, that in a US multispecialty survey of physicians including interventional cardiologists (mean age: 46.9 years), 53% of them reported having received treatment for their neck or back pain[20].

This study also explored risk factor for back pain in interventional cardiologists. We found female counterparts were associated with higher risk of back pain, which is not surprising, as males usually have better pain tolerance than females[21]. Interventional cardiologists conducting > 1 type of ICPs are more likely to develop back pain. In hospitals with high patient volume, some interventional cardiologists were trained to conduct different types of ICPs, which inevitably results in longer work hours. Significantly positive correlation was found between the personal annual ICP volume and development of back pain, indicating the impact of the lead PPE on back pain.

Persistent back pain diminishes quality of life, reduces productivity, and leads to early career termination in healthcare workers[6, 20, 22]. Therefore, mitigation of back pain is critical to meet the occupational health needs of interventional cardiologists in China.

This study also addressed the level of satisfaction with PPE and PHP needs. Interventional cardiologists are not fully satisfied with the current lead PPE due to its heavy weight and concerns about its protective efficacy against radiation exposure. These dissatisfactions, concerns and the consequential OHHs along with other factors, such as income and family, have caused over one-third of the surveyed interventional cardiologists to consider early termination of their ICP career, which is in contrary to the increasing demand of ICPs in China. Thus, corresponding solutions address these health needs and PHP needs begin to become urgent issues. For example, the Society of Interventional Radiology advised that interventional radiologists should avoid prolonged standing while on lead PPE operating in an awkward or poor posture (necessitated by leaning or bending to accomplish procedures) to prevent back pain among the profession[23]. Considering the high personal annual volume of procedures, training more interventional cardiologists to reduce personal workload can be an effective approach to alleviate their back pain burden. Lastly, most interventional cardiologists expect novel technologies to conduct ICPs without radiation exposure and wearing PPE. Fortunately, zero-fluoroscopy ablation procedures have already been developed and conducted in

real-world settings[24], mostly using non-fluoroscopic 3-D electroanatomical navigation system combined with intracardiac echocardiography and contact force technologies, which can be a promising alternative method to reduce incidence of OHH, especially body pain during ICPs.

Limitations

As a cross-sectional online survey study, several major limitations could have biased the findings. First, the survey invitation was initially distributed to interventional cardiologists attending the national cardiology conference and then circulated via several social medias. The non-random recruitment method inherently poses a higher risk of selection bias than a random recruitment method. However, it is expected that the selection bias would be minimal as the distribution of surveyed physicians reveals great regional variance among participants. Second, the absence of a mandatory request for physicians who read the invitation to complete this survey could associate the study with response bias. Third, responses to questions that require participants to recall memory or estimate (e.g., ICP workload, sick leave days due to pain in the last five years) could generate information bias. Lastly, the comorbidities information collected from the survey could be substantially under-reported as the participants were not required to provide medical evidence for their comorbidities. However, the reported pain-related OHHs should be reliable as pain is a sensory symptom.

Conclusion

This national online survey presented the health status of interventional cardiologists in China and revealed a high burden of body pain due to long working hours and wearing heavy PPE. Besides training more interventional cardiologists to reduce per-physician workload, adoption of emerging technologies without heavy lead PPE will be a promising way to reduce the OHH burden in interventional cardiologists.

ACKNOWLEDGMENTS

None

FUNDING SOURCES

None

DISCLOSURES

None

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FIGURE LEGENDS

Figure 1. The flowchart of including survey participants for data analysis.

Figure 2. Results of the multiple logistic regression analysis exploring the factors associated with back pain in the surveyed interventional cardiologists.

Table 1. Summary of the collected ICP-related information and utilization information for PPE in the surveyed interventional cardiologists.

Study group	Cardiologists	Cardiologists	Cardiologists	Cardiologists
Sample size	N=642	N=642	N=642	N=642
Variables	N	n	Mean/%	SD
Years of working for cardiology	642		13.0	7.2
Years of conducting ICP	642		8.8	6.2
Utilization of PPE (%)				
Lead clothes	642	638	99.4%	
Lead cap	642	122	19.0%	
Lead collar	642	608	94.7%	
Lead apron	642	386	60.1%	
Lead glasses	642	176	27.4%	
Personal radiation dose counter	642	339	52.8%	
Others	642	0	0.0%	
RE				
Average days of conducting ICP in a week	642		3.1	1.3
Average hours of conducting ICP in a day	641		5.0	2.8
Average hours of wearing PPE in a day	641		4.2	2.5
Average number of conducted ICP in a year	639		340.2	281.5

Table 2. Comparisons of demographics, occupational information, and lifestyle associated with surveyed interventional cardiologists and non-interventional cardiologists before and after propensity score matching.

Group	Before propensity score matching	Before propensity score matching
	Interventional cardiologists	Interventional cardiologists
Sample size	N=642	N=642
Variables	Mean/%	SD
Demographics		
Male (n, %) [a]	75.9%	
Age (years)[a]	39.9	6.7
Obesity (BMI[?]28.0)	5.9%	
Overweight (24.0[?]BMI<28.0)	35.4%	
Normal weight (18.5[?]BMI<24.0)[a]	54.4%	
Underweight (BMI<18.5)	4.4%	
Smoking history (n, %)		

Group	Before propensity score matching	Before propensity score matching
Never smoking	84.3%	
Ever smoked	8.1%	
Current smoking	7.6%	
Years of smoking[a]	1.0	4.0
Average number of cigarettes smoked per day	0.7	3.1
Drinking history (n, %)		
Never drinking	17.8%	
Occasional social drinking[a]	81.2%	
Regular drinking	1.1%	
Education degree (n, %)		
Bachelor's degree or below	22.6%	
Master's degree	51.7%	
Doctorate[a]	25.7%	
Profession title (n, %)		
Attending physician[a]	44.2%	
Associate chief physician	37.1%	
Chief physician[a]	18.7%	
Years of working in the department of cardiology	13.0	7.2

[a] Variables included in propensity score matching

Table 3. The comparisons of the OHH-related outcomes between the surveyed interventional cardiologists and non-interventional cardiologists before and after propensity score matching.

Study group	Before propensity score matching	Before propensity score matching
	Interventional cardiologists	Interventional cardiologists
Sample size	N=642	N=642
OHH	Mean/%	SD
Body pain (%)	67.3%	
Body pain location (%)		
Head	6.4%	
Neck	36.4%	
Shoulder	34.6%	
Back	54.4%	
Elbow	3.4%	
Hand	6.9%	
Buttocks	5.6%	
Knee	18.8%	
Thigh	5.6%	
Calf	8.4%	
Ankle	7.3%	
Foot	6.9%	
Pain assessment*		
Verbal pain rating scale	0.2	0.8
Severe pain (verbal pain rating scale >=3)	5.3%	
Sick leave due to body pain in the last 5 years (%)	9.8%	
Pain treatment (%)	31.0%	
Comorbidities (%)		
At least one comorbidity	43.5%	

Study group	Before propensity score matching	Before propensity score matching
Bone and joint disease	23.1%	
Cataract	3.6%	
Hypertension	12.0%	
Coronary heart disease	0.6%	
Type 2 diabetes	1.9%	
Blood disease	0.3%	
Depression	2.8%	
Anxiety	9.7%	
Malignant tumor	0.3%	
Thyroid cancer	0.3%	
Nodular disease	2.0%	
Thyroid nodules	1.1%	
Breast nodules	0.3%	
Lung nodules	0.6%	
Others	3.0%	

Supplemental Table 1 . Summary of the assessments for PPE satisfaction and PHP needs in the surveyed interventional cardiologists.

Study group	Surveyed interventional cardiologists	Sur
Sample size	N=642	N=
Variables	N	n
Concern degree of radiation exposure associated with ICP	642	
PPE satisfaction assessment		
Totally dissatisfied	642	53
Satisfied to a certain extent	642	390
Mostly satisfied	642	178
Completely satisfied	642	21
Recognition of the PPE negative health impact		
No impact	642	25
A certain impact	642	458
Strong impact	642	124
Significant impact	642	35
Limitations of PPE (n, %)		
Incomplete protection	642	475
Tedious and time-consuming for wearing	642	137
Body pressure caused by the weighted PPE	642	533
Poor comfort and disturbing ICP	642	300
unmatched size of PPE	642	225
Others	642	5
Concern assessment of radiation dose associated with ICP		
Concern for every ICP	642	207
Occasional concern	642	377
No concern at all	642	58
Willingness assessment for ICP without radiation exposure and requiring PPE	642	582
Attempts of terminating the career of conducting ICP	642	251
Reasons for the attempts of terminating the career of conducting PPE		
Unbearable back pain	251	59
Health hazards associated with radiation exposure	251	215

Study group	Surveyed interventional cardiologists	Sur
Low quality of life and stress	251	175
Family members' concerns	251	139
Unsatisfied with the incomes from conducting ICP	251	198
Other reasons	251	2