

doi: 10.13241/j.cnki.pmb.2018.04.015

有无心脏外科支持的经皮冠状动脉介入术病例特点及转归的比较分析*

张洁函^{1,2} 庄少伟² 居海宁² 于亚梅¹ 王玉华² 佟士骅² 郑兴^{1Δ}

(1 第二军医大学第一附属医院长海医院心血管内科 上海 200433;

2 上海中医药大学附属第七人民医院心血管内科 上海 200137)

摘要 目的:分析有无心脏外科支持的经皮冠状动脉介入术(PCI)病例的特点及转归差异。**方法:**回顾性分析 2308 例行 PCI 术患者的病例资料,根据心脏外科支持情况分为支持组(2031 例)、无支持组(277 例),比较两组患者的基线资料、PCI 术相关指标及主要不良心血管事件(MACE)的发生情况。**结果:**与支持组比较,无支持组患者的医疗费用明显增加,急诊 PCI、危险因素中 AMI 病史、PCI 史、疾病诊断中 STEMI 的比例明显降低,LVEF 明显升高,差异均有统计学意义($P<0.05$)。支持组以三支及以上冠脉病变以及 B、C 型复杂病变形态多见,支架置入数、左主干病变比例明显增多,靶血管 IVUS 比例检查比例、术中总并发症发生率明显降低,与无支持组比较差异均有统计学意义($P<0.05$)。两组 PCI 术后 MACE 的发生率比较差异均无统计学意义($P>0.05$)。**结论:**有无心脏外科支持的 PCI 患者的临床特点存在较大差异,无心脏外科支持的 PCI 患者以急诊手术为主,且靶血管病变相对较轻。对于低风险病例实施 PCI 手术是安全可行的,具有较高成功率,预后尚可。

关键词:经皮冠状动脉介入术;心脏外科支持;病例特点;转归

中图分类号:R541.4 文献标识码:A 文章编号:1673-6273(2018)04-672-05

Comparative Analysis of the Characteristics and Outcome of Patients Underwent PCI with or without Cardiac Surgery Support*

ZHANG Jie-han^{1,2}, ZHUANG Shao-wei², JU Hai-ning², YU Ya-mei¹, WANG Yu-hua², TONG Shi-hua², ZHENG Xing^{1Δ}

(1 Department of Cardiology, Changhai Hospital, Second Affiliated Hospital of Second Military Medical University, Shanghai, 200433;

2 Department of Cardiology, The 7th People's Hospital, Shanghai University of Traditional Chinese Medicine, Shanghai, 200137)

ABSTRACT Objective: To investigate the clinical characteristics and prognosis between patients underwent percutaneous coronary intervention (PCI) with or without cardiac surgery support. **Methods:** The clinical data of 2308 cases of patients underwent PCI were retrospectively analyzed, they were divided into the backup group ($n=2031$) and the non-backup group ($n=277$) according to the cardiac surgery support. The baseline information, PCI related indicators, and occurrence of major adverse cardiac events (MACE) in two groups were compared. **Results:** Compared with the backup group, there were significant increase in the medical costs and LVEF, decrease in the percentage of emergency PCI, history of AMI and PCI, STEMI in the non-backup group ($P<0.05$). Backup group was given priority to triple-vessel disease and over, complex lesions of type B and C, numbers of stent placement and the proportion of left main lesion were significantly increased, and the proportion of target vessel intravascular ultrasound (IVUS), the success rate of PCI, total incidence of intraoperative complications were significantly lower than those in the non-backup group ($P<0.05$). There was no significant difference in the incidence of MACE after PCI between two groups($P>0.05$). **Conclusions:** There is remarkable difference in the clinical characteristics in PCI between with or without cardiac surgery, PCI without cardiac surgery is given priority to emergency PCI with relatively milder lesion of target vessel. PCI is safe and feasible for low risk cases, and has high success rate and fair prognosis.

Key words: Percutaneous coronary intervention; Cardiac surgery backup; Characteristics; Outcome

Chinese Library Classification(CLC): R541.4 **Document code:** A

Article ID: 1673-6273(2018)04-672-05

前言

近年来,经皮冠状动脉介入术(PCI)以其操作简单、创伤小、康复快等优势已成为急性冠脉综合征(ACS)、急性心肌梗死(A-MI)等心血管疾病患者重要的治疗手段之一,其能够有效恢复心脏血流再灌注,提高患者的生存率。据统计,截至 2013 年中

国 PCI 的病例数已超过 40 万例,位居世界第二^[1-5]。由于 PCI 术是在病变的冠状动脉中实施侵入性操作,存在冠脉损伤及相关并发症的风险,严重者可导致死亡,故临床上普遍倡导在心脏外科的支持下实施 PCI 术^[6-8]。随着 PCI 技术的不断改进,因 PCI 失败而需心脏外科急救的几率依从 2.2%将至 1%以下,但关于有无心脏外科支持的 PCI 病例转归差异,目前缺乏相关的

* 基金项目:上海市科委科技支撑项目(13411950302)

作者简介:张洁函(1980-),女,医学硕士,主治医师,研究方向:心血管动脉硬化及冠脉介入手术,E-mail: hanjie_1980@126.com

Δ 通讯作者:郑兴(1957-),男,博士生导师,教授,主要研究方向:心血管内科学,E-mail: zhengxing57530@163.com

(收稿日期:2017-09-17 接受日期:2017-10-10)

比较研究^[9,10]。本研究通过回顾性分析不同医院 PCI 患者的病例资料,比较有无心脏外科支持的 PCI 病例特点及转归,旨在为 PCI 患者的诊治提供参考依据。

1 资料与方法

1.1 一般资料

收集 2015-2016 年接受 PCI 术的患者的住院病例资料,其中有心脏外科支持的长海医院和市七医院(年 PCI 量大于 1500 例)抽取 2031 例(支持组),无心脏外科支持的长海医院市七医院(年 PCI 量小于 500 例)抽取 277 例(无支持组),共计 2308 例。入组标准:(1)临床确诊的 AMI、CAS、心绞痛患者,并选择性冠状动脉造影确诊;(2)年龄 ≥ 18 岁,配合术后随访;(3)发病 7 天内行 PCI,并置入 1 枚支架以上;排除标准:(1)心脏瓣膜病等其他严重心脏疾病;(2)出血倾向及抗凝禁忌症;(3)严重多器官功能障碍或衰竭。其中,男 1528 例,女 780 例,年龄 26~93 岁,平均 (65.1 ± 7.4) 岁;稳定型心绞痛(SAP)1355 例,ACS 492 例,急性 ST 段抬高性心肌梗死(STEMI)461 例。急诊 PCI 297 例,择期 PCI 2011 例;发病至 PCI 术时间 3h~7d,平均 (3.1 ± 0.4) d。

1.2 治疗方法

所有患者 PCI 术前常规给予负荷量氯吡格雷 300 mg、阿司匹林 300 mg,同时给予瑞舒伐他汀 10 mg。按照常规 Judkins 法行冠状动脉造影确定梗死动脉后行血栓抽吸,并根据血管病变情况选择置入支架。术后常规服用氯吡格雷 75 mg/d,连续服用 12 个月以上;阿司匹林 100 mg/d,长期服用;根据患者实际情况,可给予他汀类调脂药、 β 受体阻滞剂、血管紧张素转换酶抑制剂(ACEI)等,并积极控制危险因素。PCI 术成功的判定标准^[11]:支架置入后梗死相关冠状动脉残余狭窄小于 20%,

前向血流达到 TIMI 3 级,无再次血管闭塞、心源性死亡等严重并发症。

1.3 观察指标

1.3.1 基线资料 通过查阅电子病历系统,采集患者的基本资料,包括性别、年龄、吸烟史、既往病史(高血压、糖尿病、AMI、PCI 术、脑卒中等),入院时相关检查结果,包括血糖、血脂、心肌酶谱、肌钙蛋白(CTnI)、肌酐(Cr)等,采用超声心动图,改良 Simpson 法测定左心室射血分数(LVEF)值。

1.3.2 PCI 手术相关指标 记录患者的血管病变部位、病变支数、PCI 术支架置入数、支架长度、心肌梗死溶栓试验(TIMI)血流分级变化。

1.3.3 随访 所有患者 PCI 术后均通过门诊复查、电话随访等方式,记录患者 PCI 的手术效果及远期主要不良心血管事件(MACE)的发生情况,包括心源性死亡、AMI、靶血管血运重建(TVR)和脑卒中等。

1.4 统计学方法

应用 SPSS20.0 版软件包进行统计学分析,计数资料以率表示,组间比较采用 χ^2 检验,计量资料均符合正态分布以均数 $\pm$ 标准差($\bar{x} \pm s$)表示,组间比较采用 t 检验,以 $P < 0.05$ 视为差异有统计学意义。

2 结果

2.1 心脏外科支持组和无支持组 PCI 病例的基线资料比较

与支持组比较,无支持组患者的医疗费用明显增加,AMI 病史、PCI 史、疾病诊断中 STEMI 的比例明显降低,LVEF 明显升高,差异均有统计学意义($P < 0.05$)。两组性别、年龄、其他危险因素比较差异均无统计学意义($P > 0.05$)。见表 1。

表 1 支持组和无支持组 PCI 病例基线资料比较

Table 1 Comparison of the baseline information between backup group and non-backup group

Index		Without backup group(n=277)	Backup group(n=2031)	P
Gender	Female	212(40.7)	1649(25.3)	>0.05
age(year)		65.11 ± 4.47	64.67 ± 4.86	>0.05
Medical cost(yuan)		74052.16 ± 2894.03	58876.61 ± 2574.15	<0.05
Emergency PCI[n(%)]		230(83.0)	67(3.3)	<0.05
LVEF(%)		59.92 ± 6.26	53.97 ± 5.47	<0.05
Risk factor[n(%)]	Hypertension	201(72.6)	1429(70.4)	>0.05
	Diabetes mellitus	90(32.5)	586(28.9)	>0.05
	Hyperlipemia	89(32.1)	619(30.5)	>0.05
	Smoking	172(62.1)	1365(67.2)	>0.05
	History of AMI	48(17.3)	605(29.8)	<0.05
	History of PCI	28(10.1)	320(15.8)	<0.05
	History of stroke	66(23.8)	441(21.7)	<0.05
Disease diagnose[n(%)]	SAP	146(52.7)	1209(59.5)	>0.05
	ACS	43(15.5)	449(22.1)	
	STEMI	88(31.8)	373(18.4)	

2.2 支持组和无支持组 PCI 术相关指标的比较

支持组以三支及以上冠脉病变以及 B、C 型复杂病变形态多见,支架置入数、左主干病变比例明显增多,靶血管 IVUS 比

例检查比例、术中总并发症明显降低,与无支持组比较差异均有统计学意义($P<0.05$)。两组手术时间、支架长度、PCI 成功率比较差异均无统计学意义($P>0.05$)。见表 2。

表 2 支持组和无支持组 PCI 术相关指标比较

Table 2 Comparison of the PCI related indexes between backup group and non-backup group

Index		Without backup group(n=277)	Backup group(n=2031)	P
Operation time		65.34± 10.28	64.50± 12.29	>0.05
Number of stent implantations(piece)		1.48± 0.26	1.74± 0.32	<0.05
Length of stent (mm)		26.28± 6.52	25.83± 8.64	>0.05
Number of lesion vessels[n(%)]	1-vessel	11(4.0)	33(1.6)	<0.05
	2-vessel	166(59.9)	908(44.7)	
	3-vessel and over	100(36.1)	1090(53.7)	
Type of lesion	A	70(25.3)	178(8.8)	<0.05
	B	70(25.3)	650(32.0)	
	C	137(49.4)	1203(59.2)	
Left main coronary artery lesion[n(%)]		13(4.7)	153(7.5)	<0.05
Success rate of PCI[n(%)]		263(94.9)	1917(94.4)	>0.05
IVUS for target vessel		59(21.3)	90(4.4)	<0.05
Intraoperative complications	Coronary perforation	2(0.7)	8(0.4)	<0.05
	Coronary artery dissection	2(0.7)	6(0.3)	
	Acute left heart failure	0(0)	2(0.1)	
	Ventricular arrhythmias	1(0.4)	3(0.1)	
	Hypotension	3(1.1)	12(0.6)	
	Decreased heart rate	3(1.1)	7(0.3)	
	Cardiac shock	0(0)	3(0.1)	
	Subtotal	11(4.0)	41(2.0)	

2.3 支持组和无支持组 PCI 术后 MACE 的发生情况比较

($P>0.05$)。见表 3。

两组 PCI 术后 MACE 的发生率比较差异均无统计学意义

表 3 支持组和无支持组 PCI 术后 MACE 的发生情况比较[例(%)]

Table 3 Comparison of the incidence of MACE after PCI between backup group and non-backup group[n(%)]

MACE	Without backup group(n=277)	Backup group(n=2031)	X ²	P
Cardiac death	2(0.7)	13(0.6)	0.03	>0.05
AMI	5(1.8)	48(2.4)	0.34	>0.05
TVR	18(6.5)	144(7.1)	0.13	>0.05
Stroke	8(2.9)	87(4.3)	1.20	>0.05

3 讨论

PCI 术已在国内外临床普及,成为 AMI、ACS 等心血管疾病的最有效诊疗手段。但由于其属于侵入性操作,易受到诸多方面因素的影响,且并发症不容忽视,尤其是急、危、重的并发症发生风险一直未得到有效控制^[12-14]。因此,临床上普遍主张在心外科手术条件支持下实施 PCI,以达到提高 PCI 成功率、改善患者预后的目的。近年来,PCI 术不断完善,需心脏外科手术

处理的 PCI 术相关并发症已日趋减少,有学者提出在无心脏外科支持的医院实施 PCI 术,尤其是择期 PCI 术,但其安全性与可行性尚存在较大争议。

卫生部颁布的《心血管疾病介入诊疗技术管理规范(2011 年版)》提出 PCI 术原则上只能在三级医院中开展,且有心脏大血管外科或胸外科^[15]。尽管如此,国内越来越多的医院开展 PCI 术,《中国内地 2008 年经皮冠状动脉介入治疗调查注册研究分析》中数据显示 57% 的开展 PCI 术的医院年 PCI 量不足 100

例,且此类医院多数无心脏外科作为支持。由于经济、设备条件等原因,通常选择血流动力学稳定者进行急诊 PCI 术^[16-18]。Aversano 等^[19]一项关于有/无现场心脏外科支持的 PCI 术转归的非劣效性研究表明无现场心脏外科支持的 PCI 术 6 周死亡率、9 个月 MACE 0.9%、12.1%,不劣于有现场心脏外科的 PCI 术 1.0%、11.2%。本研究结果显示无支持组以急诊 PCI 为主,心功能优于支持组,且 AMI 病史、PCI 史、以及 STEMI 的比例明显降低,但医疗费用明显增加,考虑与 PCI 量小的医院对患者的选择偏倚有关,无心脏支持组患者的病情相对较轻,病情较重或 PCI 风险较高的患者通常建议转诊至有心外科支持的医院。但由于无心外科支持的医院 PCI 术开展尚未完全成熟,成本较高,所以一定程度上增加了患者的医疗费用^[20-22]。

对 PCI 术相关指标分析结果显示支持组以三支及以上冠脉病变以及 B、C 型复杂病变形态多见,且支架置入数、左主干病变比例明显增多,说明靶血管的病变程度较重,此类患者的 PCI 难度大,风险高,与国外相关研究结果^[23-26]基本一致。受术者经验和能力的影响,靶血管 IVUS 比例检查比例、术中总并发症明显降低。2011 年,美国心脏病学会/美国心脏协会和心血管造影与介入学会(ACC/AHA 和 SCAI)更新的 PCI 指南中指出对于无心外科支持的医院实施急诊 PCI 治疗为 IIb 类,而择期 PCI 治疗为 IIIa 适应证,但临床实践中不推荐^[27]。此外,无心脏外科支持医院的 PCI 手术成功率也高达 94.9%,与有心外科支持医院的成功率相当,且术后 1 年 MACE 的发生率并未增加,两组转归比较无显著性差异。由此可见,无心外科支持下的 PCI 术具有相对的安全性。临床实践中,年 PCI 量超过 500 例医院中经验丰富的术者常参与指导年 PCI 术,一定程度上保证了 PCI 术的成功率,降低术后并发症的发生^[28-30]。

综上所述,有无心脏外科支持的 PCI 患者的临床特点存在较大差异,无心脏外科支持的 PCI 患者以急诊手术为主,且靶血管病变相对较轻,对于低风险病例实施 PCI 手术是安全可行的,具有较高成功率,预后与有心外科支持的医院相当。由于本研究随访观察时间尚短,其远期手术效果与转归差异仍有待今后进一步深入研究。

参考文献(References)

- [1] Ministry of Health of People's Republic of China. 2012 Chinese Journal of Health Informatics and Management [M]. Beijing: Peking Union Medical College Publishing House, 2012
- [2] Farooq V, Brugaletta S, Serruys PW. Contemporary and evolving risk scoring algorithms for percutaneous coronary intervention [J]. Heart, 2011, 97(12): 1902-1913
- [3] Epstein AJ, Polsky D, Yang F, et al. Coronary revascularization trends in the United States, 2001-2008 [J]. JAMA, 2011, 305(17): 1769-1776
- [4] Sachdev M, Sun JL, Tsiatis AA, et al. The prognostic importance of comorbidity for mortality in patients with stable coronary artery disease [J]. J Am Coll Cardiol, 2004, 43(4): 576-582
- [5] Singh M, Lennon RJ, Gulati R, et al. Risk scores for 30-day mortality after percutaneous Coronary intervention: new insights into causes and risk of death [J]. Mayo Clin Proc, 2014, 89(5): 631-637
- [6] Khazanie P, Liang L, Qualls LG, et al. Outcomes of Medicare beneficiaries with heart failure and atrial fibrillation [J]. J ACC Heart Fail, 2014, 2(1): 41-48
- [7] Yang EH, Guminal U, Lennon RJ, et al. Emergency coronary artery by Pass surgery for Percutaneous coronary interventions: changes in the incidence, clinical characteristics, and indications from 1979 to 2003 [J]. J Am Coll Cardiol, 2005, 46(12): 2004-2009
- [8] 胡盛寿, 张浩. 开胸介入心脏外科手术 - 微创心脏外科的新发展 [J]. 心脑血管病防治, 2006, 6(3): 135, 145
- [9] Hu Sheng-shou, Zhang Hao. Thoracotomy in cardiac surgery - the new development of minimally invasive cardiac surgery [J]. Prevention and Treatment of Cardio-Cerebral-Vascular Disease, 2006, 6(3): 135, 145
- [9] Dehmer GJ, Blankenship JC, Cilingiroglu M, et al. SCAI/ACC/AHA expert consensus document: 2014 update on percutaneous coronary Intervention without on-site surgical backup [J]. Circulation, 2014, 129(24): 2610-2626
- [10] Levine GN, Bates ER, Blankenship JC, et al. 2011 ACCF/AHA/SCAI guideline for percutaneous Coronary intervention: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions [J]. Circulation, 2011, 124(23): e574-e651
- [11] 韩雅玲. 中国经皮冠状动脉介入治疗指南(2016)解读 [J]. 中国循环杂志, 2016, 31(z2): 5-8
- [11] Han Ya-ling. interpretation of Chinese guideline for percutaneous coronary intervention (2016) [J]. Chinese Circulation Journal, 2016, 31(z2): 5-8
- [12] Lichtman JH, Wang Y, Jones SB, et al. Age and sex differences in in-hospital complication rates and mortality after percutaneous coronary intervention procedures: evidence from the NCDR [J]. Am Heart J, 2014, 167(12): 376-383
- [13] 王勇, 范书英. 冠心病介入治疗的现状和展望 [J]. 临床内科杂志, 2012, 32(1): 5-8
- [13] Wang Yong, Fan Shu-ying. Percutaneous coronary intervention: present aspects and prospect [J]. Journal of Clinical Internal Medicine, 2012, 32(1): 5-8
- [14] Peterson PN, Shetterly SM, Clarke CL, et al. Health literacy and outcomes among patients with heart failure [J]. JAMA, 2011, 305(16): 1695-1701
- [15] 中华人民共和国卫生部医政司. 心血管疾病介入诊疗技术管理规范(2011 年版) [J]. 中国医学前沿杂志(电子版), 2012, 4(2): 76-78
- [15] The ministry of health department of the People's Republic of China. Management specification of cardiovascular interventional diagnosis and treatment technology (2011) [J]. Chinese Journal of the Frontiers of Medical Science (Electronic Version), 2012, 4(2): 76-78
- [16] 苑飞, 宋现涛, 吕树铮. 中国内地 2008 年经皮冠状动脉介入治疗调查注册研究分析 [J]. 中华心血管病杂志, 2010, 38(7): 629-631
- [16] Yuan Fei, Song Xian-tao, Lv Shu-zheng. Percutaneous coronary intervention in mainland China in 2008: register results [J]. Chinese Journal of Cardiology, 2010, 38(7): 629-631
- [17] Maddox TM, Stanislawski MA, O'Donnell C, et al. Patient access and 1-year outcomes of percutaneous coronary intervention facilities with and without on-site cardiothoracic surgery: insights from the Veterans Affairs (VA) Clinical Assessment, Reporting, and Tracking (CART) program [J]. Circulation, 2014, 130(16): 1383-1391
- [18] Garg S, Anderson SG, Oldroyd K, et al. British Cardiovascular

- Intervention Society; National Institute for Cardiovascular Outcomes Research. Outcomes of percutaneous coronary intervention performed at off site versus on site surgical centers in the United Kingdom [J]. *J Am Coll Cardiol*, 2015, 66(4): 363-372
- [19] Aversano T, Lemmon CC, Liu L, et al. Outcomes of PCI at hospitals with or without on-site cardiac surgery [J]. *New England Journal of Medicine*, 2011, 97(12): 1902-1913
- [20] Dehmer GJ, Kutcher MA, Dey SK, et al. ACC-NCDR. Frequency of percutaneous coronary intervention at facilities without on-site cardiac Surgical backup-a report from the American College of Cardiology-National Cardiovascular Data Registry (ACC-NCDR)[J]. *Am J Cardiol*, 2007, 99(3): 329-332
- [21] Pride YB, Canto JG, Frederick PD, et al. Outcomes among patients with ST-segment-elevation myocardial infarction Presenting to interventional hospitals with and without on-site cardiac surgery [J]. *Circ Cardiovasc Qual Outcomes*, 2009, 2(6): 574-582
- [22] Spoon DB, Psaltis PJ, Singh M, et al. Trends in cause of death after percutaneous coronary intervention [J]. *Circulation*, 2014, 129(12): 1286-1294
- [23] Hannan EL, Zhong Y, Racz M, et al. Outcomes for Patients With ST-Elevation Myocardial Infarction in Hospitals With and Without Onsite Coronary Artery Bypass Graft Surgery[J]. *The New York State Experience Circ Cardiovasc Intery*, 2009, 2(12): 519-527
- [24] Kutcher MA, Klein LW, Ou FS, et al. National Cardiovascular Data Registry. Percutaneous coronary interventions in facilities without cardiac surgery on site: a report from the National Cardiovascular Data Registry(NCDR)[J]. *J Am Coll Cardiol*, 2009, 54(1): 16-24
- [25] Lee JM, Hwang D, Park J, et al. Percutaneous coronary intervention at centers with and without on-site surgical backup: an updated meta-analysis of 23 studies[J]. *Circulation*, 2015, 132(5): 388-401
- [26] Singh M, Holmes DR Jr, Dehmer GJ, et al. Percutaneous coronary intervention at centers with and without on-site surgery: a meta-analysis[J]. *JAMA*, 2011, 306(22): 2487-2494
- [27] Dehmer GJ, Blankenship JC, Cilengiroglu M, et al. SCAI/AHA Expert Consensus Document: 2014 update on percutaneous coronary intervention without on-site surgical backup [J]. *J Am Coll Cardiol*, 2014, 64(3): 335
- [28] Bakaeen FG, Blackstone EH, Svensson LG. Performing Percutaneous Coronary Intervention Without On-site Cardiac Surgery Is Not a License for Percutaneous Coronary Intervention Instead of Coronary Artery Bypass Grafting[J]. *JAMA Cardiol*, 2017, 2(8): 926-933
- [29] Jacobs AK, Normand SL, Massaro JM, et al. MASSCOMM Investigators. Non emergency PCI at Hospitals with or without on-site cardiac surgery[J]. *N Engl J Med*, 2013, 368(16): 1498-1508
- [30] Aversano T, Lemmon CC, Liu L. Atlantic CPORT Investigators. Outcomes of PCI at hospitals with or without on-site cardiac surgery [J]. *N Engl J Med*, 2012, 366(19): 1792-1802

(上接第 796 页)

- [25] Shamsul BS, Tan KK, Chen HC, et al. Posterolateral spinal fusion with osteogenesis induced BMSC seeded TCP/HA in a sheep model[J]. *Tissue Cell*, 2014, 46(2): 152-158
- [26] Jensen T, Schou S, Stavropoulos A, et al. Maxillary sinus floor augmentation with Bio-Oss or Bio-Oss mixed with autogenous bone as graft: a systematic review [J]. *Clin Oral Implants Res*, 2012, 23(3): 263-273
- [27] Hruschka V, Saeed A, Slezak P, et al. Evaluation of a thermoresponsive polycaprolactone scaffold for in vitro three-dimensional stem cell differentiation [J]. *Tissue Eng Part A*, 2015, 21(1-2): 310-319
- [28] Hyeongseok Kim, Hye Min Kim, Ji Eun Jang, et al. Osteogenic Differentiation of Bone Marrow Stem Cell in Poly(Lactic-co-Glycolic Acid) Scaffold Loaded Various Ratio of Hydroxyapatite[J]. *Int J Stem Cells*, 2013, 6(1): 67-74
- [29] Zhang P, Hong Z, Yu T, et al. In vivo mineralization and osteogenesis of nanocomposite scaffold of poly (lactide-co-glycolide) and hydroxyapatite surface-grafted with poly (L-lactide)[J]. *Biomaterials*, 2009, 30(1): 58-70
- [30] B.S. Shamsula, K.K. Tanb, H.C. Chenc, Posterolateral spinal fusion with osteogenesis induced BMSC seeded TCP/HA in a sheep model [J]. *Tissue Cell*, 2014, 46(2): 152-158
- [31] Fu TS, Chang YH, Wong CB. Mesenchymal stem cells expressing baculovirus-engineered BMP-2 and VEGF enhance posterolateral spine fusion in a rabbit model[J]. *Spine J*, 2015, 15(9): 2036-2044
- [32] Campoccia D, Visai L, Renò F. Bacterial adhesion to poly-(D,L)lactic acid blended with vitamin E: toward gentle anti-infective biomaterials [J]. *Biomed Mater Res A*, 2015, 103(4): 1447-1458
- [33] Miron RJ, Zhang Q, Sculean A. Osteoinductive potential of 4 commonly employed bone grafts [J]. *Clin Oral Invest*, 2016, 20(8): 2259-2265