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生物力学与材料

# 容量及压力控制通气模式对俯卧位腰椎融合术患者血流动力学的影响

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**【摘　要】目的：**探讨容量控制通气模式(VCV)和压力控制通气模式(PCV)对俯卧位腰椎融合术患者血流动力学的影响。**方法：**择期行后入路腰椎融合术患者根据不同通气模式随机分为两组，分别为VCV组($n$=19)及PCV组($n$=18)。记录俯卧位后每10 min至120 min(Tprone10, Tprone20, …, Tprone120)的血流动力学及呼吸力学指标。**结果：**俯卧位时PCV组的平均动脉压高于VCV组[(82.21±2.28) mmHg *vs* (75.72±2.04) mmHg]($P$<0.05)，同样潮气量下，PCV组的气道峰压及肺顺应性优于VCV组($P$<0.05)。**结论：**俯卧位腰椎手术中PCV对呼吸及循环系统干扰相对较小，更有利于术中血压的维持。

**【关键词】**腰椎；容量控制通气；压力控制通气；俯卧位；血流动力学
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# Hemodynamic variables in patients undergoing lumbar spine fusion surgery in prone position: volume-controlled ventilation *versus* pressure-controlled ventilation

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**Abstract: Objective** To compare the hemodynamic effect of volume-controlled ventilation (VCV) *versus* pressure-controlled ventilation (PCV) in patients undergoing lumbar spine fusion surgery in prone position. **Methods** Thirty-seven patients scheduled for posterior lumbar spine surgery were divided to VCV group ($n$=19) and PCV group ($n$=18) according to the different mechanical ventilation modes. The respiratory and hemodynamic variables from 10 minutes after prone position till 120 minutes (Tprone10, Tprone20, …, Tprone120) were recorded and compared. **Results** When the patient was in prone position, the mean arterial pressure in PCV group was higher than that in VCV group [(82.21±2.28) mmHg *vs* (75.72±2.04) mmHg, $P$<0.05]. With the same tidal volume, the dynamic compliance and peak airway pressure in PCV group were higher than those in VCV group ($P$<0.05). **Conclusion** With better respiratory mechanic and hemodynamic stability, PCV is superior to VCV as a mechanical ventilation mode for lumbar spine surgery in prone position.

**Keywords:** lumbar vertebra; volume-controlled ventilation; pressure-controlled ventilation; prone position; hemodynamics

## 前　言

俯卧位为后入路腰椎融合术提供良好的手术视野，但俯卧位并非生理体位，体位垫的使用使心脏处于最高点并使腔静脉受压[1]，腹部受压膈肌上抬，胸廓活动受限导致顺应性下降[2]，胸腔内压增加，静脉回流减少致使左室前负荷降低[3-5]，术中低血压非常常见[5]。合理的通气模式可以在一定程度上减少对循环功能的影响，有利于血流动力学平稳。本研究通过比较接受择期后入路腰椎融合术的患者在容量控制通气模式(VCV)和压力控制通气模式(PCV)下循环功能的监测指标，探讨两种通气模式对循环功能的影响。

## 1　材料与方法

### 1.1　一般资料

本研究已获得东南大学附属中大医院伦理委员会批准(2014ZDSYLL076.0)及临床实验注册(注册号：

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ChiCTR-TRC-14005086),并与患者签署知情同意书。选取择期后入路腰椎融合术(1~2个间隙)患者37例,年龄18~70岁,ASA I~Π级,所有患者均无明显心肺脑肾、糖尿病等病史,无明显胸廓畸形、肥胖(BMI≥30 kg/m$^2$)、低蛋白血症或贫血。根据术中机械通气模式不同,随机分为两组,VCV组19例,PCV组18例。

### 1.2 麻醉方法

麻醉诱导:咪达唑仑0.03~0.05 mg/kg,丙泊酚0.5~1.0 mg/kg,舒芬太尼0.4~0.5 μg/kg,顺式阿曲库铵0.15 mg/kg。VCV组,吸入氧浓度百分比($F_iO_2$):70%~80%,潮气量($V_T$):8 mL/kg,呼吸频率(RR):12~30次/min,呼气末$CO_2$分压($P_{ET}CO_2$)在35~45 mmHg;PCV组,根据8 mL/kg的$V_T$设置吸入峰压,通过调节呼吸频率维持$P_{ET}CO_2$维持在35~45 mmHg。麻醉维持:七氟醚1.0%~1.5%,丙泊酚2~4 mg/kg·h$^{-1}$,瑞芬太尼0.1~0.2 μg/kg·min$^{-1}$,顺式阿曲库铵0.10~0.15 mg/kg·h$^{-1}$,根据麻醉深度调控丙泊酚及瑞芬太尼用量维持脑电双频指数(BIS)值在40~50。术中静脉输注乳酸钠林格及羟乙基淀粉(二者比例2:1,速度4 mL/kg·h$^{-1}$),其中总量的三分之一在转为俯卧位之前输注完毕。手术结束前30 min停止输注顺式阿曲库铵及七氟醚吸入,术毕停用丙泊酚及瑞芬太尼入PACU拔管。

### 1.3 观察指标

记录手术时间、出入量,麻醉诱导后10 min(Tsupine)、转为俯卧位后10 min至120 min内每10 min(Tprone10, Tpron20, …, Tprone120)以及术毕恢复仰卧位后10 min(Tsupine2)的平均动脉压(MAP)、中心静脉压(CVP)、心排量(CO)、体循环血管阻力指数(SVRI)作为血流动力学指标。记录术中气道峰压及内源性PEEP并计算肺动态顺应性作为呼吸力学指标并于俯卧位后1 h做动脉血气分析记录氧合指数。

### 1.4 统计学方法

采用SPSS 19.0软件进行统计学处理。计量资料以均数±标准差来表示,组间比较用两因素重复测量数据的方差分析,不同组相同时间点的比较用多重因素的方差分析。

## 2 结 果

两组患者年龄、体表面积、术中补液量、出血、尿量及BIS值均无统计学差异(表1)。血流动力学指标:PCV组MAP高于VCV组,两组心率(HR)、CVP、CO及SVRI均无统计学差异(表2)。呼吸力学指标:VCV组气道峰压高于PCV组,动态肺顺应性低于PCV组,PCV组氧合指数高于VCV组(表3)。

表1 两组患者一般情况及术中出入量、BIS值比较($\bar{x}\pm s$)

Tab.1 General information of patients and intraoperative variables (*Mean±SD*)

| Item | VCV group (*n*=19) | PCV group (*n*=18) | *P* value |
|---|---|---|---|
| Age (years) | 59.85±11.10 | 55.35±9.57 | 0.538 |
| BSA/m$^2$ | 1.72±0.16 | 1.69±0.97 | 0.053 |
| Hydration/mL | 2 145.00±654.11 | 2 129.41±427.95 | 0.117 |
| Blood loss/mL | 482.50±336.96 | 294.11±262.72 | 0.111 |
| Urine/mL | 477.50±336.96 | 481.17±248.79 | 0.748 |
| Operative time/min | 170.25±54.95 | 158.05±36.95 | 0.255 |
| BIS value | 44.99±1.04 | 44.62±1.04 | 0.063 |

VCV: Volume-controlled ventilation; PCV: Pressure-controlled ventilation; BSA: Body surface area; BIS: Bispectral index

## 3 讨 论

本研究比较了后入路腰椎融合术中VCV和PCV对患者血流动力学的影响。结果显示与VCV组相比,PCV组患者MAP更高且肺顺应性更好。后入路腰椎融合术中俯卧位需要体位垫来支撑躯干免受挤压伤,但也会部分限制胸腹活动度,导致胸腔内压及腹腔内压升高,静脉回流受阻,回心血量下降,血压降低[3-5]。VCV模式下,由于肺顺应性下降,需要不断增加$V_T$来维持足够的通气,$V_T$的增加导致气道压升高[6]以及胸腔内压升高,进一步减少静脉回流,加重了机械通气对血流动力学的影响[7-9]。随着手术时间的延长,往往需要血管活性药物维持血压。PCV是一种时间切换压力控制模式,俯卧位脊柱外科手术中,维持同样的$V_T$水平,PCV的通气模式比VCV可以提供较低的气道峰压、更好的肺动态顺应性及氧合[10-11],从而降低胸腔内压及肺血管阻力,

表2 两组血流动力学指标比较（$\bar{x} \pm s$）

**Tab.2 Comparison of hemodynamic index between two groups (*Mean±SD*)**

| Hemodynamic index | VCV group (*n*=19) | PCV group (*n*=18) | *P* value |
|---|---|---|---|
| HR/bpm | 64.22±2.15 | 64.18±2.27 | 0.990 |
| MAP/mmHg | 75.72±2.04 | 82.21±2.28 | 0.041 |
| CVP/mmHg | 5.46±0.60 | 6.44±0.72 | 0.302 |
| CO/L·$min^{-1}$ | 3.93±0.12 | 4.14±0.14 | 0.296 |
| SVRI | 2 427.41±145.00 | 2 478.67±150.47 | 0.808 |

No difference was found in HR, CVP, CO and SVRI between the two groups. MAP in PCV group was higher than that in VCV group (*P*=0.041). HR: Heart rate; MAP: Mean arterial pressure; CVP: Central venous pressure; CO: Cardiac output; SVRI: Systemic vascular resistance index

表3 两组呼吸参数及呼吸力学指标比较（$\bar{x} \pm s$）

**Tab.3 Ventilatory and oxygenation parameters between two groups (*Mean±SD*)**

| Ventilatory and oxygenation parameters | VCV group (*n*=19) | PCV group (*n*=18) | *P* value |
|---|---|---|---|
| $V_T$/mL | 519.41±14.38 | 523.39±14.38 | 0.846 |
| RR (breaths/min) | 9.31±0.31 | 8.42±0.311 | 0.050 |
| $P_{ET}CO_2$/mmHg | 34.06±0.79 | 35.42±0.79 | 0.232 |
| Ppeak/$cmH_2O$ | 18.08±0.47 | 16.13±0.50 | 0.008 |
| Auto PEEP/$cmH_2O$ | 3 | 3 | - |
| Cdyn /mL·$cmH_2O^{-1}$ | 34.23±1.70 | 40.74±1.58 | 0.007 |
| $PaO_2/F_iO_2$/mmHg | 435.48±80.54 | 529.56±120.04 | 0.006 |

Except for $V_T$, $P_{ET}CO_2$ and auto PEEP, significant differences were found in Ppeak, Cdyn and $PaO_2/F_iO_2$ between two groups. $V_T$: Vital volume; RR: Respiratory rate; $P_{ET}CO_2$: End-tidal carbon dioxide pressure; Ppeak: Peak airway pressure; Auto PEEP: Auto positive end expiratory pressure; Cdyn: Dynamic lung compliance; $PaO_2/F_iO_2$: Arterial partial pressure of oxygen *versus* fraction of inspired oxygen

改善右心室功能[12]。Poon等[5]研究认为，俯卧位时血压降低的主要原因是心排量及每搏量下降，因此临床麻醉中要尽量减少影响心排血量的因素。机械通气时，即使容量充足，正压通气也会影响静脉回流从而降低心排血量[9, 13-19]。本研究结果表明，俯卧位时与VCV组相比，PCV患者气道压低肺顺应性更好，PCV组MAP明显高于VCV组，PCV组的CO、CVP均高于VCV组（*P*>0.05），SVRI无明显差别。维持同样$V_T$水平时，PCV组较低的气道压减少了胸腔内压升高的幅度，减少了机械通气对静脉回流的影响，从而有利于血压的维持。因此，俯卧位后入路腰椎融合术中PCV比CVC更有利于维持血流动力学平稳。

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