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冠状动脉 CTA 结合动态心电图夜间 ST 段趋势图诊断冠状动脉硬化性心脏病的价值研究 *

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摘要 目的:探讨冠状动脉 CTA 结合动态心电图夜间 ST 段趋势图对冠状动脉硬化性心脏病(冠心病)的诊断价值。**方法:**回顾性分析 2022 年 1 月-2023 年 2 月在我院疑似冠心病的患者 104 例,所有患者均行冠状动脉造影、冠状动脉 CTA、动态心电图及临床相关实验室检查。以冠状动脉造影结果作为诊断冠心病的金标准,分析比较冠状动脉 CTA、动态心电图夜间 ST 段趋势图及两者联合诊断冠心病的诊断效能和一致性。**结果:**104 例疑似冠心病的患者确诊 93 例(89.42%)。冠状动脉 CTA 诊断冠心病的敏感性为 90.32%,特异性为 72.73%,阳性预测值为 96.55%,阴性预测值为 47.06%,准确率为 88.46%,与冠状动脉造影的 Kappa 值为 0.813,一致性好。动态心电图夜间 ST 段趋势图诊断冠心病的敏感性为 84.95%,特异性为 63.64%,阳性预测值为 95.18%,阴性预测值为 33.33%,准确率为 82.69%,与冠状动脉造影的 Kappa 值为 0.724,一致性较好。有夜间 ST 段动态改变的冠心病检出率(84.95%,79/93)明显高于无夜间 ST 段动态改变的冠心病检出率(15.05%,14/93),差异有统计学意义($P<0.001$)。冠状动脉 CTA 结合动态心电图夜间 ST 段趋势图诊断冠心病的敏感性为 96.77%,特异性为 90.91%,阳性预测值为 98.90%,阴性预测值为 76.92%,准确率为 96.15%,与冠状动脉造影的 Kappa 值为 0.923,一致性好。**结论:**冠状动脉 CTA 结合动态心电图夜间 ST 段趋势图诊断冠心病的临床价值优于冠状动脉 CTA 或动态心电图夜间 ST 段趋势图单独检查。

关键词:冠状动脉 CTA;动态心电图;夜间 ST 段趋势图;冠状动脉硬化性心脏病

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Study on the Value of Coronary Artery CTA Combined with ST Segment Trend Chart of Dynamic Electrocardiogram at Night in the Diagnosis of Coronary Atherosclerotic Heart Disease*

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ABSTRACT Objective: To investigate the diagnostic value of coronary artery CTA combined with ST segment trend chart of dynamic electrocardiogram at night in coronary atherosclerotic heart disease (coronary heart disease). **Methods:** A retrospective analysis of 104 patients with suspected coronary heart disease in our hospital from January 2022 to February 2023 was performed. All patients underwent coronary angiography, coronary CTA, dynamic electrocardiogram and clinical related laboratory tests. The results of coronary angiography were used as the gold standard for the diagnosis of coronary heart disease. The diagnostic efficacy and consistency of coronary CTA, ST segment trend chart of dynamic electrocardiogram at night and the combination of the two in the diagnosis of coronary heart disease were analyzed and compared. **Results:** 93 (89.42%) of 104 suspected coronary heart disease cases were confirmed. The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of coronary artery CTA in the diagnosis of coronary heart disease were 90.32%, 72.73%, 96.55%, 47.06%, and 88.46%, which were in good agreement with the Kappa value 0.813 of coronary artery angiography. The sensitivity, specificity, positive predictive value and negative predictive value were 84.95%, 63.64%, 95.18%, 33.33% and 82.69% in the diagnosis of coronary artery disease by ST segment trend chart of dynamic electrocardiogram at night, which was in good agreement with the Kappa value 0.724 of coronary artery angiography. The detection rate of coronary heart disease with dynamic changes of ST segment at night (84.95%,79/93) was significantly higher than that no dynamic changes of ST segment at night (15.05%,14/93), and the difference was statistically significant ($P<0.001$). The sensitivity, specificity, positive predictive value,

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negative predictive value and accuracy of coronary CTA combined with ST segment trend chart of dynamic electrocardiogram at night in the diagnosis of coronary heart disease were 96.77%, 90.91%, 98.90%, 76.92% and 96.15%. The Kappa value of coronary angiography was 0.923, and the consistency was good. **Conclusion:** The clinical value of coronary CTA combined with ST segment trend chart of dynamic electrocardiogram at night in the diagnosis of coronary heart disease is better than that of coronary CTA or ST segment trend chart of dynamic electrocardiogram at night alone.

Key words: Coronary CTA; Dynamic electrocardiogram; ST segment trend chart at night; Coronary atherosclerotic heart disease

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前言

冠状动脉硬化性心脏病简称冠心病,通常是指冠状动脉血管发生粥样硬化引起冠状动脉管腔的狭窄或阻塞,从而导致心肌缺血、缺氧或坏死的心脏病,具有慢性迁延性和高复发性的特点,死亡率、卒中和再住院率均较高^[1,2]。目前冠心病公认诊断标准为冠状动脉造影,但其为有创操作、具有放射性、费用也较高等导致其在冠心病的应用中受到一定限制^[3]。冠状动脉计算机断层血管造影(CTA)已成为一种诊断疑似冠状动脉疾病患者的无创检查方法。但部分患者钙化斑块较重,影响冠状动脉管腔狭窄程度的判断,此类患者冠状动脉 CTA 只能作为参考^[4,5];部分患者因心率较快等影响冠状动脉 CTA 检查质量;而部分患者冠状动脉 CTA 检查可能显示冠状动脉血管未见阻塞性冠状动脉疾病,这类患者中有很大一部分存在冠状动脉微血管功能障碍^[6]。动态心电图的监测便宜且无创,即使患者无症状,也能识别心肌缺血的短暂发作(即心肌梗死的前兆),通过软件分析动态心电图并提取出患者 ST 段的变化,得到的 ST 段趋势图可以分析提高准确性,更加直观显示心肌缺血事件的发生,包括发生的时间、频率、持续时间和严重程度等^[7,8]。基于此,本研究回顾性分析我院诊断为冠心病患者的冠状动脉 CTA 及动态心电图等临床资料,探讨将冠状动脉 CTA 结合动态心电图夜间 ST 段趋势图在诊断冠心病中的临床价值,以期对冠心病患者的早期发现、早诊断及早治疗提供诊断和治疗依据。

1 资料与方法

1.1 一般资料

回顾性分析 2022 年 1 月-2023 年 2 月在我院疑似冠心病的患者 104 例,男性 64 例,女性 40 例,年龄 46-83 岁,平均(61.25±5.69)岁。纳入标准:所有患者均行冠状动脉造影、冠状动脉 CTA、动态心电图及临床相关实验室检查;具有心绞痛病史;动态心电图监测时间≥24 h,其中夜间 ST 段趋势图为晚上 10 点至次日凌晨 7 点,白天 ST 段趋势图为早晨 7 点至晚上 10 点,动态心电图所接导联电极部位均正确,录图基线平稳无干扰。排除标准:具有严重心力衰竭、先天性心脏病、心肌病、严重心律失常等患者;具有冠状动脉造影禁忌症者;长期服用多种抗心律失常药物者;存在认知功能障碍者。本研究经我院医学伦理委员会批准。

1.2 冠状动脉 CTA 检查

采用 GE256 排 512 层螺旋 CT 机进行扫描,扫描范围从气管分叉至心脏膈下 2 cm 左右,扫描时嘱患者屏气避免心脏运动伪影影响观察。扫描参数设置为管电压 120 kV,管电流 500 mA,

螺距 0.982,重建视野为 25 cm×20 cm,重建层厚为 0.625 mm。按患者标准体重由肘静脉注射碘帕醇 60 mL,注射速率为 5.0 mL/s,碘帕醇注射完后再注射 30 mL 生理盐水。随后采用对比剂跟踪触发技术扫描。扫描结束后将图像传至后处理工作站进行图像后处理。图像分析和评估由 2 名具有 8 年以上冠状动脉诊断工作经验的医师进行,意见不一致时协商讨论一致为准。诊断标准:患者右冠、左主干、前降支、回旋支四条主要血管中有一处或一处以上血管管腔狭窄程度≥50%,即可诊断为冠心病^[9]。

1.3 动态心电图监测及夜间 ST 段趋势图判定

采用深圳市理邦精密仪器股份有限公司 SE-2003/2012 动态心电图工作站,佩戴动态心电图期间应避免劳累、出汗、剧烈运动等,持续监测 24 h,监测完成后由人工进行回放,观察 ST 段偏移情况。阳性判读标准:ST 段压低呈水平状或下斜>0.1 mV,40 岁以上男性 ST 段抬高≥0.2 mV,女性 V2-V3 导联抬高≥0.15 mV 或其他导联抬高≥0.1 mV,且持续时间≥1 min,两次发作间隔时间≥1 min。根据 ST 段趋势图的形态改变,分为"城墙样"改变和"峰型"改变。

1.4 诊断标准

冠状动脉造影诊断标准:患者右冠、左主干、前降支、回旋支四条主要血管中有一处或一处以上血管管腔狭窄程度≥50%,即可诊断为冠心病。冠状动脉 CTA 联合动态心电图诊断标准:两者有一项判断为冠心病即可诊断。

1.5 统计学方法

采用 SPSS22.0 统计分析软件。计数资料以频数和百分率表示,计数资料采用卡方检验。Kappa 检验分析两种检查方法的一致性,>0.75 表明一致性好,0.40-0.75 表明一致性较好,<0.40 表明一致性差。 $P<0.05$ 为差异有统计学意义。

2 结果

2.1 冠状动脉造影诊断结果

104 例疑似冠心病的患者中,经冠状动脉造影确诊 93 例(89.42%),未确诊 11 例(10.58%)。

2.2 冠状动脉 CTA 诊断结果

冠状动脉 CTA 诊断冠心病的敏感性为 90.32%(84/93),特异性为 72.73%(8/11),阳性预测值为 96.55%(84/87),阴性预测值为 47.06%(8/17),准确率为 88.46%[(84+8)/104]。冠状动脉 CTA 与冠状动脉造影的 Kappa 值为 0.813,一致性好。见表 1,图 1,图 2。

2.3 动态心电图夜间 ST 段趋势图诊断结果

动态心电图夜间 ST 段趋势图诊断冠心病的敏感性为 84.95%(79/93),特异性为 63.64%(7/11),阳性预测值为

95.18% (79/83), 阴性预测值为 33.33% (7/21), 准确率为 82.69% [(79+7)/104]; 有夜间 ST 段动态改变的冠心病检出率 (84.95%, 79/93) 明显高于无夜间 ST 段动态改变的冠心病检出率 (15.05%, 14/93), 差异有统计学意义 ($\chi^2=14.407, P<0.001$)。动态心电图夜间 ST 段趋势图与冠状动脉造影的 Kappa 值为 0.724, 一致性较好。见表 2, 图 1, 图 2。

表 1 冠状动脉 CTA 诊断结果
Table 1 Diagnostic results of coronary CTA

Coronary CTA	Coronary angiography		Total
	Positive	Negative	
Positive	84	3	87
Negative	9	8	17
Total	93	11	104

表 2 动态心电图夜间 ST 段趋势图诊断结果
Table 2 Diagnosis results of ST segment trend chart of dynamic electrocardiogram at night

ST segment trend chart of dynamic electrocardiogram at night	Coronary angiography		Total
	Positive	Negative	
Dynamic changes of ST segment at night	79	4	83
No dynamic change of ST segment at night	14	7	21
Total	93	11	104

2.4 冠状动脉 CTA 结合动态心电图夜间 ST 段趋势图诊断结果

冠状动脉 CTA 结合动态心电图夜间 ST 段趋势图诊断冠心病的敏感性为 96.77% (90/93), 特异性为 90.91% (10/11), 阳性预测值为 98.90% (90/91), 阴性预测值为 76.92% (10/13), 准确率为 96.15% [(90+10)/104]。动态心电图夜间 ST 段趋势图与冠状动脉造影的 Kappa 值为 0.923, 一致性好。见表 3。

3 讨论

冠心病是由冠状动脉狭窄或闭塞引起的心肌缺血、缺氧和坏死性心脏病, 严重者可引起急性冠状动脉综合征 (ACS), 在我国其死亡率在各种心血管疾病中居首位^[10,11]。心肌缺血常常提示患者心脏事件风险增加, 预后较差, 因此其早期诊断对于判断冠心病的进展和指导临床干预 (如介入治疗) 具有重要意义^[12]。动态心电图是评估心肌缺血的一种常用方法, 可作为一种常规的筛选方法, 可以完全记录心肌缺血的发生情况和特点^[13]。冠状动脉造影则一直是评估冠状动脉血管狭窄程度和严重程度的首选方法。但其为有创检查, 且成本较高, 重复性差。而目前冠状动脉 CTA 已成为一种无创诊断冠状动脉血管狭窄程度的有效方法^[14,15], 并能够通过计算机断层扫描得出的血流储备分数 (FFRCT) 来评估冠状动脉狭窄程度及其生理反应。冠状动脉 CTA 因钙化斑块影响可能会高估冠状动脉管腔狭窄的严重程度, 导致较高的死亡风险预测; 然而, FFRCT 弥补了这一缺陷, 让其对心肌缺血和血运重建的评估标准更加准确^[16,17]。基于此, 为寻找一种准确、无创、可普及性好、患者接受度高的诊断方法, 本研究将冠状动脉 CTA 和动态心电图夜间 ST 段趋势图联合应用, 结果显示, 两者联合应用能提高冠心病的诊断准确性, 达到与冠状动脉造影相一致的诊断结果, 适用于临床的普及。

分析认为动态心电图 ST 段的出现常提示发生心肌缺血。

ST 段趋势图可在不同心率条件下进行自动调整, 对 R 波出现后的 60 ms 或 80 ms 开始连续记录, 由软件提取 ST 段并计算偏移量, 最终得出 ST 段趋势图^[18]。动态心电图的监测即便宜也无创, 患者即使无症状也能识别是否存在心肌缺血的短暂发作, ST 段趋势图的变化能直观反映心肌缺血事件的特点, 包括发生的时间、频率、持续时间和严重程度, 明确疾病的类型, 初步提高检出率, 为临床治疗和诊断提供科学依据, 并尽快采取预防措施。冠心病患者 ST 段常常会发生动态改变, 提示心肌细胞缺血的发生, 而 ST 段可降低或升高, 为帮助临床医师快速诊断, 可通过软件自动获取 ST 段动态趋势图的变化。12 导联动态心电图可通过对比扫描 ST 段趋势图来确定心肌缺血的发生时间, 动态观察 ST 段和 QTc 区间的形状, 并提供 12 导联 ST 段的交互式三维颜色趋势图, 有助于临床了解心肌缺血发作过程中 ST 段变化的特点^[19]。夜间 ST 段趋势图呈 "城墙样" 改变, 可能与动态心电图改变不具特异性有关, 不仅与心肌缺血相关, 还与体位因素、患者精神及神经因素、扫描技术等有关, 从而影响心电信号的采集。夜间 ST 段趋势图呈 "峰型" 改变, 多由于冠状动脉粥样硬化导致血管痉挛, 管腔进一步狭窄心肌细胞缺血加重所致。ST 段趋势图可以通过 ST 波动趋势、心率变异性、心律等电信号数据分析并反映出心脏活动状态和静息状态的变化。通过分析 ST 段趋势图波动与时间的关系, 监测患者血流动力学的变化, 确定病变部位, 以确定患者是否为无症状心肌缺血^[20]。另一方面, 在心律失常的诊断中, ST 段趋势图可以了解心律失常的发生情况、持续时间、发作频率等特点, 明确疾病类型, 初步提高检出率, 为临床治疗和诊断提供科学依据, 并尽快采取预防措施^[21,22]。此外, 动态心电图适用于不能忍受剧烈运动的老年患者, 也能减少对其活动的限制, 更容易为患者所接受, 应用更广泛^[23,24]; 还可帮助临床了解以往胸痛的诱因, 如情绪躁动和饮酒^[25], 从而为临床干预方案的制定提供指

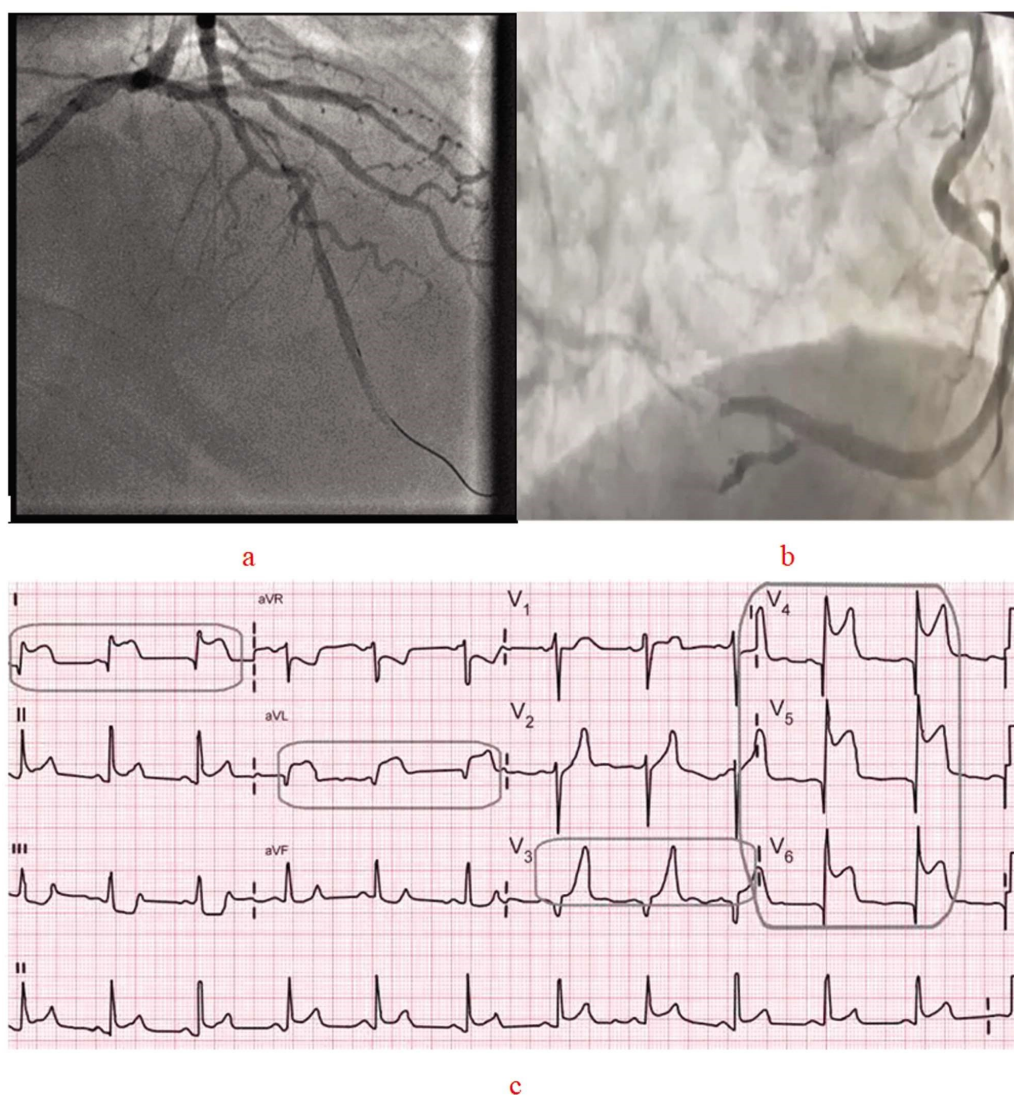


图1 某患者冠状动脉造影及动态心电图

Fig.1 Coronary angiography and dynamic electrocardiogram of a patient

注:患者男性,55岁,冠状动脉造影(图1a-b)显示:冠脉分布呈右冠优势型,冠脉走行区可见钙化影。前降支、旋支管腔中重度狭窄。动态心电图(图1c)显示:I、aVL、V3-V6导联ST段抬高,II、III、aVF导联ST段压低。

Note: The patient was a 55-year-old male. Coronary angiography (Figure 1a-b) shows that the distribution of the coronary artery was dominated by the right coronary artery, and calcification can be seen in the coronary artery running area. Moderate to severe stenosis in the lumen of the anterior descending and circumflex branches. The dynamic electrocardiogram (Figure 1c) shows that I, aVL, V3-V6 lead ST segment elevation. ST segment depression in II, III, aVF.

表3 冠状动脉 CTA 结合动态心电图夜间 ST 段趋势图诊断结果

Table 3 Diagnostic results of coronary CTA combined with ST segment trend chart of dynamic electrocardiogram at night

Coronary CTA combined with ST segment trend chart of dynamic electrocardiogram at night	Coronary angiography		Total
	Positive	Negative	
Positive	90	1	91
Negative	3	10	13
Total	93	11	104

导。也有研究认为单独应用动态心电图的临床价值有限,与 MSCT 心肌灌注成像^[26]等检查方法存在一定的差距。常规冠状动脉 CTA 目前已较广泛应用于临床冠心病的诊断中,但其一个重要的局限性是仅评估基于血管狭窄的严重程度和血管中最严重的管腔阻塞,忽略了冠状动脉 CTA 提供的其他半定量评分,也应考虑整个冠状动脉分支的整体评估。除了冠状动脉

管腔的评估外,冠状动脉 CTA 还可以提供冠状动脉壁内动脉粥样硬化斑块亚型的定性和定量评估,从而进一步细化除狭窄严重程度之外的风险预测^[27,28]。本研究显示,动态心电图夜间 ST 段趋势图诊断冠心病的准确率为 82.69%,冠状动脉 CTA 诊断冠心病的准确率为 88.46%,而两者联合诊断冠心病的准确率为 96.15%。提示单独应用冠状动脉 CTA 或动态心电图夜

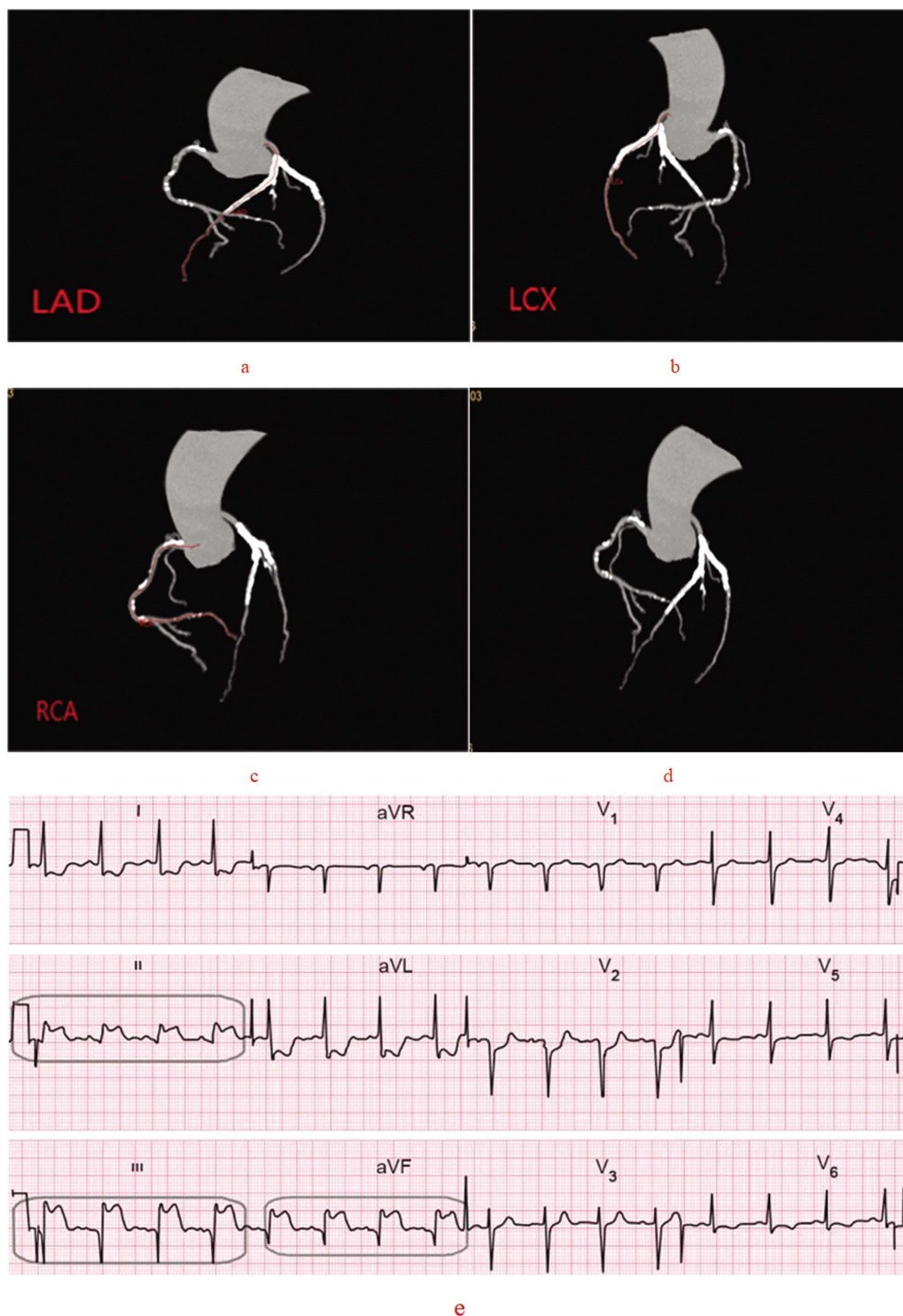


图2 某患者冠状动脉 CTA 及动态心电图

Fig.2 Coronary CTA and dynamic electrocardiogram of a patient

注:患者男性,58岁,冠状动脉 CTA 三维后处理最大密度投影(MIP)图(图 2a-d)显示:冠脉支架术后,冠脉分布呈右冠优势型,冠脉走行区可见钙化影。前降支近中段可见金属支架影,支架内管腔通畅,中段局部管腔管腔行走于心肌内。回旋支近段可见金属支架影,支架内管腔通畅。支架内远段钙化及非钙化斑块并管腔重度狭窄,右冠状动脉多发钙化及非钙化斑块并管腔中度狭窄。动态心电图(图 2e)显示 II、III、aVF 导联 ST 段抬高, I、aVL、V5、V6 导联 ST 段压低。

Note: The patient was a 58-year-old male. Coronary CTA three-dimensional post-processing maximum intensity projection (MIP) images (Figure 2a-d) showed that after coronary stenting, the coronary artery distribution was right coronary dominant, and calcification was seen in the coronary artery. The proximal and middle segments of the anterior descending branch showed metal stent shadow, and the lumen in the stent was unobstructed, the local lumen of the middle segment walked in the myocardium. The proximal segment of the circumflex branch showed metal stent shadow, and the lumen in the stent was unobstructed. In the distal segment of the stent, calcified and non-calcified plaques and lumen severe stenosis, multiple calcified and non-calcified plaques in the right coronary artery and lumen moderate stenosis. Dynamic electrocardiogram (Figure 2e) showed ST segment elevation in lead II, III, aVF and depressed ST level in leads I, aVL, V5 and V6.

间 ST 段趋势图对诊断冠心病均是有效的,可作为判断疾病进展、严重程度和指导临床干预的具体参考依据;但仍有一定的漏诊率和误诊率,而两者联合诊断可更全面、更准确地评价冠心病的发生情况和特点,两种检查方法各自发挥其特长,弥补彼此不足,从而得到更好的诊断效率。

综上所述,冠状动脉 CTA 结合动态心电图夜间 ST 段趋势图诊断冠心病的临床价值优于冠状动脉 CTA 或动态心电图夜间 ST 段趋势图单独检查,可作为临床准确、无创、广泛应用的联合检查方法,具有较好的普及性和患者接受度,能提高冠心病的诊断准确性,达到与冠状动脉造影相一致的诊断结果。

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