

基于磁共振成像检查测量直肠周围脂肪含量构建中低位直肠癌根治术后复发预测模型及其应用价值

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【摘要】 目的 探讨中低位直肠癌根治术后复发的影响因素,以及基于磁共振成像(MRI)检查测量直肠周围脂肪含量构建预测模型及其应用价值。**方法** 采用回顾性队列研究方法。收集2016年12月至2021年12月天津市人民医院收治的254例中低位直肠癌患者的临床病理资料;男188例,女66例;年龄为(61±9)岁。患者均行直肠癌根治术和盆腔常规MRI检查。观察指标:(1)随访情况及直肠周围脂肪定量测量。(2)中低位直肠癌根治术后肿瘤复发影响因素分析。(3)中低位直肠癌根治术后肿瘤复发列线图预测模型构建及评价。正态分布的计量资料以 $\bar{x} \pm s$ 表示,偏态分布的计量资料以 M (范围)或 $M(Q_1, Q_3)$ 表示。计数资料以绝对数表示。单因素和多因素分析均采用COX回归模型。使用rms软件包(4.1.3版本)生成列线图 and 校准曲线图,使用survival软件包(4.1.3版本)计算C-index,采用ggDCA软件包(4.1.3版本)进行决策曲线分析。**结果** (1)随访情况及直肠周围脂肪定量测量。254例患者术后均获得随访,随访时间为41.0(1.0~59.0)个月,随访期间81例术后肿瘤复发,肿瘤复发时间为15.0(1.0~43.0)个月,173例术后肿瘤未复发。81例术后肿瘤复发患者,术前直肠系膜筋膜包裹体积、术前直肠系膜脂肪面积、术前直肠后系膜厚度分别为159.1(68.6, 266.5) cm^3 、17.0(5.1, 34.4) cm^2 、1.2(0.4, 3.2) cm ;173例术后肿瘤未复发患者上述指标分别为178.5(100.1, 310.1) cm^3 、19.8(5.3, 40.2) cm^2 、1.6(0.3, 3.7) cm 。(2)中低位直肠癌根治术后肿瘤复发影响因素分析。多因素分析结果显示:肿瘤分化程度为低分化、肿瘤病理学N分期为N1~2期、直肠后系膜厚度 ≤ 1.43 cm、磁共振壁外血管侵犯阳性、肿瘤侵犯周围结构是影响中低位直肠癌根治术后肿瘤复发的独立危险因素(风险比=1.64, 2.20, 3.19, 1.69, 4.20, 95%可信区间为1.03~2.61, 1.29~3.74, 1.78~5.71, 1.02~2.81, 2.05~8.63, $P < 0.05$)。(3)中低位直肠癌根治术后肿瘤复发列线图预测模型构建及评价。根据多因素分析结果,纳入肿瘤分化程度、肿瘤病理学N分期、直肠后系膜厚度、磁共振壁外血管侵犯、肿瘤侵犯周围结构,构建中低位直肠癌根治术后肿瘤复发列线图预测模型,得分总和对应术后肿瘤复发概率。列线图的C-index值为0.80,具有较好的预测精度。校准曲线显示:列线图预测模型的预测能力良好。决策曲线显示:列线图预测模型有明显净获益率时对应预测概率阈值范围较广,该模型具有较好临床实用性。**结论** 肿瘤分化程度为低分化、肿瘤病理学N分期为N1~2期、直肠后系膜厚度 ≤ 1.43 cm、磁共振壁外血管侵犯阳性、肿瘤侵犯周围结构是影响中低位直肠癌根治术后肿瘤复发的独立危险因素;基于MRI检查测量直肠周围脂肪含量构建其列线图预测模型可良好预测患者术后肿瘤复发情况。

【关键词】 直肠肿瘤; 中低位; 高分辨磁共振成像; 直肠后系膜厚度; 预测模型; 列线图

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Construction of recurrence prediction model after radical resection of middle and low rectal cancer based on magnetic resonance imaging measurement of perirectal fat content and its application value

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[Abstract] Objective To investigate the influencing factors of recurrence after radical resection of middle and low rectal cancer, and to establish a prediction model based on magnetic resonance imaging (MRI) measurement of perirectal fat content and investigate its application value.

Methods The retrospective cohort study was constructed. The clinicopathological data of 254 patients with middle and low rectal cancer who were admitted to Tianjin People's Hospital from December 2016 to December 2021 were collected. There were 188 males and 66 females, aged (61±9)years. All patients underwent radical resection of rectal cancer and routine pelvic MRI examination. Observation indicators: (1) follow-up and quantitative measurement of perirectal fat content; (2) factors influencing tumor recurrence after radical resection of middle and low rectal cancer; (3) construction and evaluation of the nomogram prediction model of tumor recurrence after radical resection of middle and low rectal cancer. Measurement data with normal distribution were represented as $Mean \pm SD$, and measurement data with skewed distribution were represented as M (rang) and $M(Q_1, Q_2)$. Count data were described as absolute numbers. Univariate and multivariate analyses were conducted using the COX regression model. The rms software package (4.1.3 version) was used to construct the nomogram and calibration curve. The survival software package (4.1.3 version) was used to calculate the C-index. The ggDCA software package (4.1.3 version) was used for decision curve analysis.

Results (1) Follow-up and quantitative measurement of perirectal fat content. All 254 patients were followed up for 41.0(range, 1.0–59.0)months after surgery. During the follow-up period, there were 81 patients undergoing tumor recurrence with the time to tumor recurrence as 15.0(range, 1.0–43.0)months, and there were 173 patients without tumor recurrence. The preoperative rectal mesangial fascia envelope volume, preoperative rectal mesangial fat area, preoperative rectal posterior mesangial thickness were 159.1(68.6,266.5)cm³, 17.0(5.1,34.4)cm², 1.2(0.4,3.2)cm in the 81 patients with tumor recurrence, and 178.5(100.1,310.1)cm³, 19.8(5.3,40.2)cm² and 1.6(0.3,3.7)cm in the 173 patients without tumor recurrence. (2) Factors influencing tumor recurrence after radical resection of middle and low rectal cancer. Results of multivariate analysis showed that poorly differentiated tumor, tumor pathological N staging as N1–N2 stage, rectal posterior mesangial thickness ≤1.43 cm, magnetic resonance extra mural vascular invasion, tumor invasion surrounding structures were independent risk factors of tumor recurrence after radical resection of middle and low rectal cancer (*hazard ratio*=1.64, 2.20, 3.19, 1.69, 4.20, 95% *confidence interval* as 1.03–2.61, 1.29–3.74, 1.78–5.71, 1.02–2.81, 2.05–8.63, $P<0.05$). (3) Construction and evaluation of the nomogram prediction model of tumor recurrence after radical resection of middle and low rectal cancer. Based on the results of multivariate analysis, the tumor differentiation, tumor pathological N staging, rectal posterior mesangial thickness, magnetic resonance extra mural vascular invasion, tumor invasion surrounding structures were included to construct the nomogram prediction model of tumor recurrence after radical resection of middle and low rectal cancer. The total score of these index in the nomogram prediction model corresponded to the probability of post-operative tumor recurrence. The C-index of the nomogram was 0.80, indicating that the prediction model with good prediction accuracy. Results of calibration curve showed that the nomogram prediction model with good prediction ability. Results of decision curve showed that the prediction probability threshold range was wide when the nomogram prediction model had obvious net benefit rate, and the model had good clinical practicability. **Conclusions** Poorly differentiated tumor,

tumor pathological N staging as N1–N2 stage, rectal posterior mesangial thickness ≤ 1.43 cm, magnetic resonance extra mural vascular invasion, tumor invasion surrounding structures are independent risk factors of tumor recurrence after radical resection of middle and low rectal cancer. Nomogram prediction model based on MRI measurement of perirectal fat content can effectively predict the probability of postoperative tumor recurrence.

【Key words】 Rectal neoplasms; Middle and low; High resolution magnetic resonance imaging; Rectal posterior mesangial thickness; Prediction model; Nomogram

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直肠癌发病率较高,且手术治疗后容易复发^[1-3]。中低位直肠癌因肿瘤位置低、根治手术难度大,术后肿瘤复发转移风险更高,严重影响患者预后^[4]。新辅助治疗联合全直肠系膜切除术的标准治疗模式可降低直肠癌患者术后复发率,但仍有 10%~15% 的患者术后发生难治性骨盆复发^[5-6]。已有的研究结果显示:部分临床及病理因素与直肠癌术后复发相关,但其预测效能有限,且获取术后病理学特征存在滞后性^[7-11]。MRI 检查具有较高的软组织分辨能力,可清晰显示直肠系膜及系膜筋膜等结构^[12]。已有的研究结果证实:脂肪组织和肿瘤关系密切,可影响患者预后^[13-20]。已有研究结果显示:运用影像组学方法提取直肠周围脂肪组学特征及定量测量脂肪含量,可预测直肠癌新辅助治疗疗效及远期预后^[21-22]。本研究回顾性分析 2016 年 12 月至 2021 年 12 月天津市人民医院收治的 254 例中低位直肠癌患者的临床病理资料,探讨根治术后复发的影响因素,以及基于 MRI 检查测量直肠周围脂肪含量构建预测模型及其应用价值。

资料与方法

一、一般资料

采用回顾性队列研究方法。收集 254 例中低位直肠癌患者的临床病理资料;男 188 例,女 66 例;年龄为(61±9)岁。患者均行直肠癌根治术和盆腔常规 MRI 检查。本研究通过天津市人民医院伦理委员会审批,批号为 2021 年快审第 C15 号。患者及家属均签署知情同意书。

二、纳入标准和排除标准

纳入标准:(1)经电子肠镜及术后组织病理学检查明确诊断为中低位直肠癌并行直肠癌根治术。(2)术前肿瘤未转移。(3)临床病理资料完整。

排除标准:(1)有心、肺、脑、血液系统疾病等手

术禁忌证。(2)既往腹腔广泛粘连。(3)合并妊娠。(4)合并其他恶性肿瘤。(5)姑息性切除术。(6)行新辅助治疗。(7)肛管癌、家族性息肉病及多器官、双原发癌。(8)临床病理资料缺失。

三、研究方法

(一)MRI 检查方法

盆腔常规 MRI 检查设备应用 3.0 T 超导型 MRI 扫描设备,18 通道体部相控阵表面线圈。患者取仰卧位,扫描范围自髂骨上缘至耻骨联合下缘水平。扫描序列:(1)矢状位快速自旋回波 T₂ 加权成像,扫描参数为重复时间/回波时间 7 200/96 ms、视野 280 mm×280 mm、层厚 5 mm、层间距 0.5 mm、矩阵 320×320。(2)快速自旋回波 T2 加权成像,上述扫描参数分别为 450/86 ms、420 mm×420 mm、6 mm、0.6 mm、384×384。(3)冠状位快速自旋回波 T₂ 加权成像,上述扫描参数分别为 3 500/82 ms、300 mm×225 mm、4 mm、0.4 mm、448×336。(4)轴位高分辨率 T2 加权成像,上述扫描参数分别为 5 600/104 ms、200 mm×200 mm、3 mm、0.3 mm、384×384。

(二)图像分析

2 位具有 10 年盆腔 MRI 检查诊断经验的放射科医师双盲独立分析患者 MRI 检查图像,存在分歧时,通过协商最终确定。测量及评估指标包括:(1)肿瘤位置采用文献[23]的方法测量,即起点为肿瘤下缘,终点为外括约肌下缘连线,测量平行于下段直肠长轴及肛管的折线距离(图 1A)。(2)肿瘤最大径:在 T2 加权成像矢状位上测量肿瘤最大径(图 1B)。(3)磁共振环周切缘:根据文献[24]的方法测量。其指在 MRI 检查测量肿瘤、阳性淋巴结或肿瘤沉积物距离直肠系膜筋膜的最短距离,其 < 1 mm 提示为阳性(图 1C)。(4)磁共振壁外血管侵犯(图 1D):根据文献[25-26]的方法测量。(5)直肠后系膜厚度:在 T2 加权成像轴位上识别坐骨棘相邻

2 个平面,分别测量直肠后缘至骶骨前缘的直线距离,2 个平面所得值的平均值即为最终肠系膜脂肪厚度(图 1E)。(6)直肠系膜脂肪面积:在 T2 加权成像轴位上识别坐骨棘相邻 2 个平面,分别测量相应平面直肠系膜筋膜以内及同层直肠横截面面积,两者面积之差为每个平面的直肠系膜脂肪面积,再取 2 个平面的直肠系膜脂肪面积平均值即最终直肠系膜脂肪面积(图 1E)。(7)直肠系膜筋膜包裹体积:在 T2 加权成像正中矢状位图像上识别距离肛缘 10 cm 处肠周脂肪平面作为第 1 个平面,向下至齿状线所在平面作为最后 1 个平面,运用 OsiriX MD Pixmeo Sarl 2015 软件(2015 版本)勾画各平面肠周脂肪并测量,最后得到相应节段直肠系膜筋膜包裹体积(图 1F)。

四、观察指标和评价标准

观察指标:(1)随访情况及直肠周围脂肪定量测量包括获得随访的患者例数、随访时间、肿瘤复发情况、术前直肠系膜筋膜包裹体积、术前直肠系膜脂肪面积、术前直肠后系膜厚度。(2)中低位直肠癌根治术后肿瘤复发影响因素分析:年龄、性别、BMI、吸烟史、饮酒史、糖尿病史、手术类型、CEA、CA19-9、Alb、肿瘤占肠腔环周比、肿瘤分化程度、肿

瘤病理学 T 分期、肿瘤病理学 N 分期、直肠系膜筋膜包裹体积、直肠系膜脂肪面积、直肠后系膜厚度、磁共振壁外血管侵犯、磁共振环周切缘、肿瘤距肛缘距离、肿瘤最大径、肿瘤侵犯周围结构。(3)中低位直肠癌根治术后肿瘤复发列线图预测模型构建及评价:根据多因素分析结果构建中低位直肠癌根治术后肿瘤复发列线图预测模型、计算列线图 C-index 值、运用校准曲线和决策曲线评估模型预测效能。

评价标准:直肠癌术后复发定义为直肠癌患者行根治术后原发灶以外再次出现与直肠癌相关的再发癌。无复发生存时间指从肿瘤切除术后到第 1 次复发时间。

五、随访

采用门诊和电话方式进行随访,了解患者术后生存情况。随访时间截至 2021 年 12 月。

六、统计学分析

应用 IBM SPSS Statistic 22.0 统计软件及 R 软件(4.1.3 版本)进行分析。正态分布的计量资料以 $\bar{x} \pm s$ 表示,偏态分布的计量资料以 $M(\text{范围})$ 或 $M(Q_1, Q_3)$ 表示。计数资料以绝对数表示。单因素和多因素分析均采用 COX 回归模型。使用 rms 软件包(4.1.3

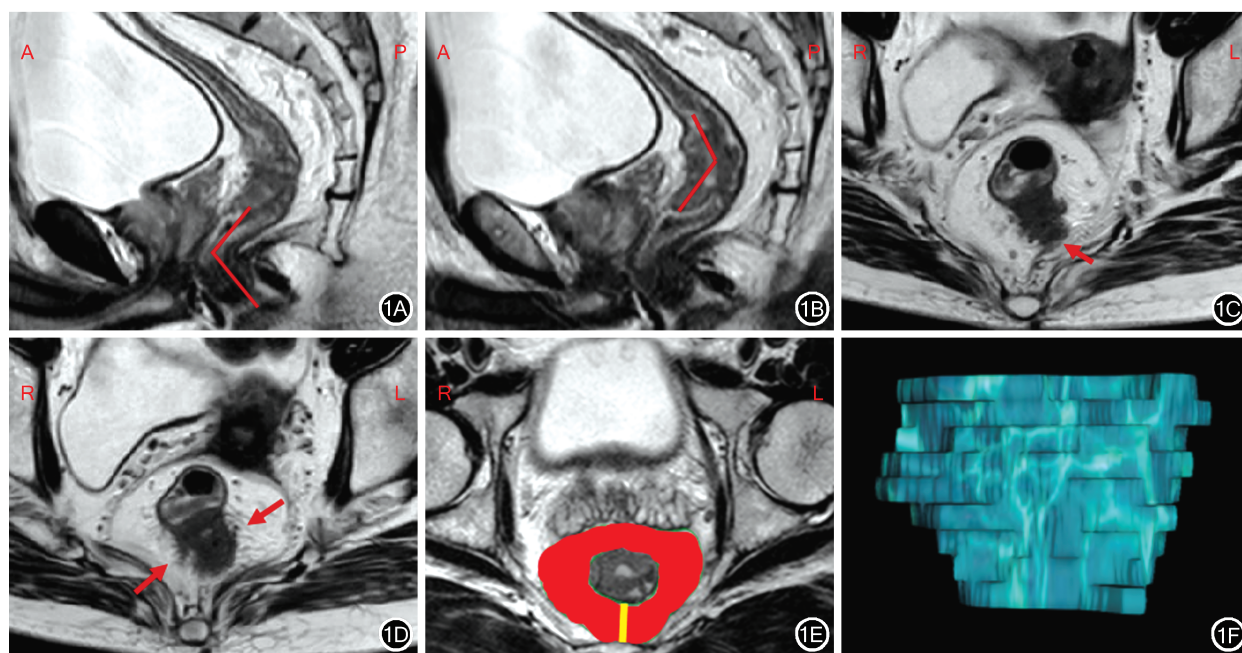


图 1 磁共振成像检查评估直肠癌患者影像学相关指标 1A:肿瘤位置测量(红线);1B:肿瘤最大径测量(红线);1C:肿瘤环周切缘阳性(箭头);1D:直肠壁外血管侵犯阳性(箭头);1E:直肠系膜脂肪面积(红色区域)及直肠后系膜厚度测量(黄线);1F:直肠系膜筋膜包裹体积示意图

Figure 1 Evaluation of imaging related indicators in rectal cancer patients based on magnetic resonance imaging 1A: Tumor location measurement (red line); 1B: Tumor diameter measurement (red line); 1C: Circumferential resection margin positive (arrow); 1D: Extra mural vascular invasion positive (arrow); 1E: Measurement of rectal mesangial fat area (red area) and rectal posterior mesangial thickness (yellow line); 1F: Diagram of rectal mesangial fascia envelope volume

版本)生存列线图和校准曲线图,使用 survival 软件包(4.1.3 版本)计算 C-index,采用 ggDCA 软件包(4.1.3 版本)进行决策曲线分析。 $P<0.05$ 为差异有统计学意义。

结 果

一、随访情况及直肠周围脂肪定量测量

254 例患者术后均获得随访,随访时间为 41.0 (1.0~59.0)个月,随访期间 81 例术后肿瘤复发,肿瘤复发时间为 15.0(1.0~43.0)个月,173 例术后肿瘤未复发。81 例术后肿瘤复发患者术前直肠系膜筋膜包裹体积、术前直肠系膜脂肪面积、术前直肠后系膜厚度分别为 159.1(68.6, 266.5) cm^3 、17.0(5.1, 34.4) cm^2 、1.2(0.4, 3.2) cm ; 173 例术后肿瘤未复发患者上述指标分别为 178.5(100.1, 310.1) cm^3 、19.8(5.3, 40.2) cm^2 、1.6(0.3, 3.7) cm 。

二、中低位直肠癌根治术后肿瘤复发影响因素分析

单因素分析结果显示:CEA、CA19-9、肿瘤分化程度、肿瘤病理学 T 分期、肿瘤病理学 N 分期、直肠系膜筋膜包裹体积、直肠系膜脂肪面积、直肠后系膜厚度、磁共振壁外血管侵犯、肿瘤侵犯周围结构是影响中低位直肠癌根治术后肿瘤复发的影响因素($P<0.05$);年龄、性别、BMI、吸烟史、饮酒史、糖尿病史、手术类型、Alb、肿瘤占肠腔环周比、磁共振环周切缘、肿瘤距肛缘距离、肿瘤最大径不是影响中低位直肠癌根治术后肿瘤复发的影响因素($P>0.05$)。见表 1。

多因素分析结果显示:肿瘤分化程度为低分化、肿瘤病理学 N 分期为 N1~2 期、直肠后系膜厚度 $\leq 1.43\text{ cm}$ 、磁共振壁外血管侵犯阳性、肿瘤侵犯周围结构是影响中低位直肠癌根治术后肿瘤复发的独立危险因素($P<0.05$)。见表 2。

表 1 影响 254 例行中低位直肠癌根治术患者术后肿瘤复发的单因素分析(例)

Table 1 Univariate analysis of tumor recurrence in 254 patients undergoing radical resection of middle and low rectal cancer (case)

临床病理因素	赋值	术后肿瘤复发(81 例)	术后肿瘤未复发(173 例)	风险比(95%可信区间)	P 值
年龄 ^a	-	-	-	1.00(0.98~1.03)	0.888
性别					
男	1	59	129	1.11(0.68~1.81)	0.671
女	0	22	44		
体质量指数 ^a	-	-	-	0.96(0.89~1.03)	0.246
吸烟史					
是	1	28	48	1.30(0.83~2.06)	0.256
否	0	53	125		
饮酒史					
是	1	32	57	1.24(0.79~1.93)	0.349
否	0	49	116		
糖尿病史					
是	1	10	23	0.92(0.48~1.79)	0.807
否	0	71	150		
手术类型					
开腹手术	1	37	65	1.15(0.84~1.59)	0.285
腹腔镜手术	0	44	108		
癌胚抗原($\mu\text{g/L}$)					
>11.34	1	24	20	2.17(1.35~3.50)	0.001
≤ 11.34	0	57	153		
CA19-9(kU/L)					
>7.4	1	48	79	1.68(1.08~2.62)	0.023
≤ 7.4	0	33	94		
白蛋白(g/L)					
<40	1	12	19	1.37(0.74~2.54)	0.310
≥ 40	0	69	154		

续表 1

临床病理因素	赋值	术后肿瘤复发(81例)	术后肿瘤未复发(173例)	风险比(95%可信区间)	P值
肿瘤占肠腔环周比					
≥1/2	1	67	152	1.57(0.63~3.92)	0.333
<1/2	0	14	21		
肿瘤分化程度					
中分化和高分化	0	40	134	2.92(1.89~4.53)	<0.001
低分化	1	41	39		
肿瘤病理学T分期					
T3~4期	1	73	119	3.30(1.59~6.85)	0.001
T1~2期	0	8	54		
肿瘤病理学N分期					
N1~2期	1	54	53	3.65(2.30~5.81)	<0.001
N0期	0	27	120		
直肠系膜筋膜包裹体积(cm ³)					
≤141.05	1	33	27	2.57(1.65~4.01)	<0.001
>141.05	0	48	146		
直肠系膜脂肪面积(cm ²)					
≤15.96	1	40	44	2.26(1.46~3.50)	<0.001
>15.96	0	41	129		
直肠后系膜厚度(cm)					
≤1.43	1	65	70	4.58(2.65~7.92)	<0.001
>1.43	0	16	103		
磁共振壁外血管侵犯					
阳性	1	37	29	3.06(1.98~4.75)	<0.001
阴性	0	44	144		
磁共振环周切缘					
阳性	1	46	105	0.90(0.58~1.39)	0.625
阴性	0	35	68		
肿瘤距肛缘距离 ^a	-	-	-	1.05(0.94~1.17)	0.404
肿瘤最大径 ^a	-	-	-	1.01(0.86~1.19)	0.908
肿瘤侵犯周围结构					
是	1	10	1	5.20(2.66~10.16)	<0.001
否	0	71	172		

注:^a为连续变量,术后肿瘤复发患者年龄、体质量指数、肿瘤距肛缘距离、肿瘤最大径分别为(61±10)岁、(24±3)kg/m²、(6.0±2.1)cm、(4.2±1.4)cm,术后肿瘤未复发患者上述指标分别为(61±9)岁、(25±3)kg/m²、(5.7±1.9)cm、(4.1±1.2)cm;“-”为此项无

表 2 影响 254 例行中低位直肠癌根治术患者术后肿瘤复发的多因素分析

Table 2 Multivariate analysis of tumor recurrence in 254 patients undergoing radical resection of middle and low rectal cancer

临床病理因素	b 值	标准误	Wald 值	风险比	95% 可信区间	P 值
肿瘤分化程度为低分化	0.49	0.24	4.27	1.64	1.03~2.61	0.039
肿瘤病理学N分期为N1~2期	0.79	0.27	8.40	2.20	1.29~3.74	0.004
直肠后系膜厚度≤1.43 cm	1.16	0.30	15.29	3.19	1.78~5.71	<0.001
磁共振壁外血管侵犯阳性	0.53	0.26	4.08	1.69	1.02~2.81	0.043
肿瘤侵犯周围结构	1.44	0.37	15.31	4.20	2.05~8.63	<0.001

三、中低位直肠癌根治术后肿瘤复发列线图预测模型构建及评价

根据多因素分析结果,纳入肿瘤分化程度、肿瘤病理学N分期、直肠后系膜厚度、磁共振壁外血

管侵犯、肿瘤侵犯周围结构,构建中低位直肠癌根治术后肿瘤复发列线图预测模型,得分总和对应术后肿瘤复发概率。见图 2。

列线图的 C-index 值为 0.80,具有较好的预测

精度。校准曲线显示:列线图预测模型的预测能力良好。见图3。决策曲线显示:列线图预测模型有明显净获益率时对应预测概率阈值范围较广,该模型具有较好临床实用性。见图4。

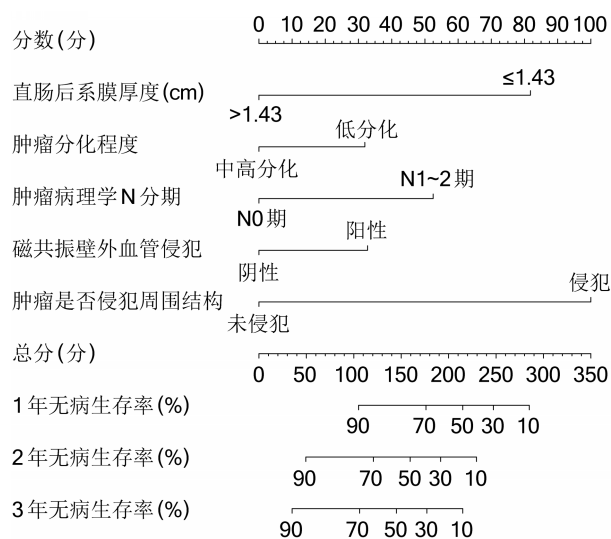


图2 行中低位直肠癌根治术患者术后肿瘤复发列线图预测模型

Figure 2 Nomogram prediction model of tumor recurrence in patients after radical resection of middle and low rectal cancer

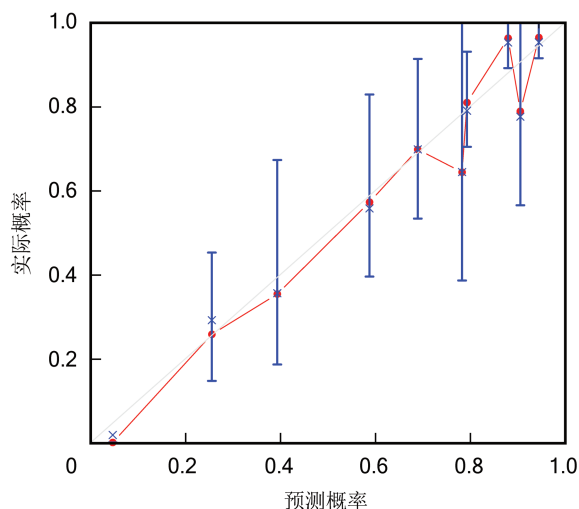


图3 中低位直肠癌患者术后肿瘤复发的校准曲线

Figure 3 Calibration curve of nomogram prediction model in predicting postoperative recurrence of middle and low rectal cancer

讨论

中低位直肠癌根治术后肿瘤复发是直肠癌治疗失败的主要原因之一。了解直肠癌根治术后肿瘤复发人群的临床及影像学特点,及时调整随访和治疗策略,利于改善患者预后^[27]。已有的研究结果显示:肿瘤低分化、肿瘤分期晚及壁外血管侵犯阳

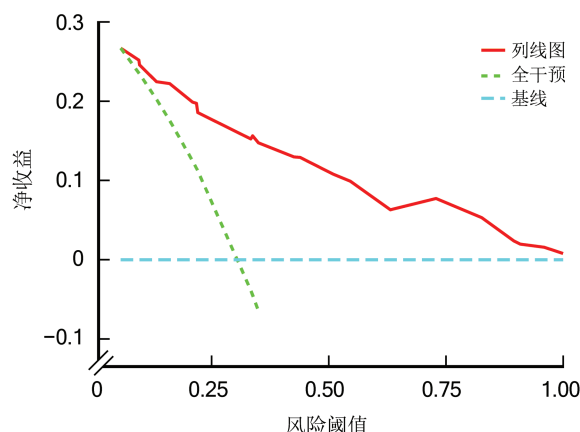


图4 中低位直肠癌患者术后肿瘤复发的临床决策曲线

Figure 4 Clinical decision curve of nomogram prediction model in predicting postoperative recurrence of middle and low rectal cancer

性均会增加患者术后复发转移风险^[28-29]。

肿瘤与周围脂肪组织的相互作用备受关注^[21,27,30]。本研究结果显示:直肠后系膜厚度 ≤ 1.43 cm是影响中低位直肠癌根治术后肿瘤复发的独立危险因素。这与既往研究结果一致^[31]。这可能与轻度肥胖或超重患者(包括内脏脂肪较丰富患者)拥有足够营养储备,能够抵抗术后化疗的不良反应和其他并发症,增加术后化疗概率,降低术后肿瘤复发转移有关^[32]。直肠周围脂肪可能在肿瘤周围形成屏障作用,阻挡肿瘤向外侵袭,且直肠系膜脂肪含量越多可增加患者环周切缘阴性率^[31,33]。直肠系膜脂肪也可以作为局部肿瘤扩散的缓冲剂,防止直肠系膜内微淋巴结转移^[34-35]。直肠癌术后肿瘤复发率降低,可能与脂肪组织的内分泌作用相关。Murono等^[36]的研究结果显示:脂肪细胞具有分泌作用,可以在周围形成微环境,这种微环境可阻碍肿瘤细胞生长,但其具体生化以及免疫相关作用机制还有待进一步研究。Dirat等^[37]的研究结果显示:肿瘤周围脂肪组织受肿瘤影响会出现脂质含量下降,脂肪细胞标志物表达降低,以及主要由促炎性脂肪因子和细胞外基质相关分子过度表达等变化。但也有研究结果显示:较大直肠后系膜厚度和骨盆跨度会增加术中出血量及手术时间,从而增加手术难度,导致术后复发风险提高^[38]。

列线图模型可预测患者预后以及淋巴结转移^[39-46]。已有的术后肿瘤复发预测模型构建均基于肿瘤病理学相关因素。但病理学指标的获取在时间上相对滞后,不能及时干预处理,导致治疗效

果欠佳。本研究融合直肠周围脂肪含量相关指标构建中低位直肠癌根治术后肿瘤复发列线图预测模型,可快捷、直观评估患者术后肿瘤复发概率,具有较好的预测价值。临床医师可根据该模型对患者进行肿瘤复发风险分层,筛选高危患者,并制订个性化随访、治疗策略。

综上,肿瘤分化程度为低分化、肿瘤病理学N分期为N1~2期、直肠后系膜厚度 ≤ 1.43 cm、磁共振壁外血管侵犯阳性、肿瘤侵犯周围结构是影响中低位直肠癌根治术后肿瘤复发的独立危险因素;基于MRI检查测量直肠周围脂肪含量构建其列线图预测模型可良好预测患者术后肿瘤复发情况。

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