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# 犬单侧输尿管梗阻时肾内动脉血流动力的变化

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提 要 目的:观测单侧输尿管梗阻家犬双肾内动脉血流动力变化,为诊断输尿管梗阻提供理论依据。方法:彩色多普勒超声对实验组8例单侧输尿管结扎家犬及8例正常对照家犬在术前及术后1~20 d行双肾血流动力及实时超声观测,测定双肾内动脉阻力指数(RI)、搏动指数(PI),并与病理检查及肾盂压力结果对比。结果:RI与PI有高度相关性($r=0.967$, $P<0.001$);实验组梗阻肾RI值(≥0.58)显著高于术前及对照组肾RI值(<0.58)($P<0.001$);实验组梗阻肾与对侧健肾RI差值(≥0.1)显著高于对照组双肾RI差值(<0.1)($P<0.001$);实验组术后对侧健肾RI较对照组肾RI低($P<0.001$);RI与肾积水程度、肾盂压力无关;梗阻肾肾内动脉管壁增厚、管腔狭窄可能为RI升高的原因。结论:彩色多普勒超声观测输尿管梗阻肾肾内动脉血流动力改变,对诊断输尿管梗阻有重要意义。

关键词 彩色多普勒超声;输尿管梗阻;阻力指数(RI);搏动指数(PI)
中图法分类号 R691.2

动物实验已证实多普勒超声在诊断急性输尿管梗阻中的作用[1],在此利用多普勒超声观测单侧输尿管梗阻家犬肾内动脉血流动力在输尿管梗阻后1~20 d的变化情况,并与实时超声(US)、病理检查、肾盂压力结果对比,为正确诊断输尿管梗阻提供理论依据。

## 1 材料与方法

### 1.1 动物模型

16只健康成年家犬(雌性10只、雄性6只,体重7.7~12.5 kg),随机等分为对照组及实验组,禁食24 h,3%戊巴比妥钠静脉麻醉(1 mg/kg),脱毛,消毒,实验组在肾门下3~5 cm处结扎左侧输尿管,对照组仅暴露左侧肾及输尿管后缝合切口。动物术后适量进食、水,以保持动物生理需要量及水、电解质平衡,并注意消毒伤口及抗感染。

### 1.2 检测方法

1.2.1 肾盂压力的测定 暴露输尿管,在距肾门下6~8 cm处将一灌满生理盐水的细管经输尿管插至输尿管肾盂交界处,细管后接压力计,测取肾盂压力。实验组左肾初始肾盂压力于结扎输尿管前测定,术后20 d测左肾终末肾盂压力与右肾肾盂压力,对照组术后20 d测双肾肾盂压力。

1.2.2 超声检查 动物在术前、术后1 2 5 10 15 20 d行彩色多普勒超声检查,检查时均麻醉至嗜睡状态,室温保持在18℃~20℃,通过控制麻醉程度、输液速度等方法,保持动物心率、呼吸、肛温稳定(心率100~140次/min 呼吸16~22次/min 肛温38℃~40℃),以维持血流动力状态稳定。ALOKA SSD-680型彩色超声显像仪,探头频率7.5 MHz,观测双肾及输尿管,彩色超声引导,脉冲多普勒在肾叶间动脉或肾弓状动脉处取样(取样容积1~2 $mm^3$),获取至少三个形态稳定的多普勒频谱,测量收缩期最高峰值(s)、舒张期最低峰值(d)及平均速度(v),计算RI PI,RI=(s-d)/s,PI=(s-d)/v,每只肾在3~5个不同点测取5个RI PI值,再取其平均值。

1.2.3 病理检查 术后20 d处死动物,观测双肾体积、肾盂、肾实质厚度及输尿管情况,每只肾在正常肾实质或肾实质病变严重处取组织块,行显微病理观察。

1.2.4 统计学处理 实验结果用单因素方差分析及两两比较的方法行统计学处理。

## 2 实验结果

### 2.1 病理结果

实验组梗阻肾充血、水肿,体积明显大于对侧非梗阻肾及对照组肾,梗阻部位以上输尿管及肾盂扩张。梗阻肾集合管及远曲小管扩张,上皮细胞浊肿变性,部分上皮细胞萎缩,肾间质有较多的淋巴细胞及中性细胞浸润,肾小球萎缩、消失,肾内小动脉管壁增厚,管腔狭窄。

### 2.2 肾盂压力结果

术后20 d梗阻肾肾盂压力与术前及对照组差异不显著($P>0.05$);实验组非梗阻肾肾盂压力与对照组差异不显著($P>0.05$)。见表1

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表 1 各组肾肾盂压力变化情况 ($\bar{x}\pm s$)

**Tab 1 Changes of the pressurre of renal peluis in different groups ($\bar{x}\pm s$)**

| Group | | Pre-operation (mmHg)* | Post-operation 20 d (mmHg)* |
|---|---|---|---|
| Control | Left kidney | —— | 12.89± 5.23 |
| | Right kidney | —— | 12.1± 3.13 |
| Experiment | Obstructed kidney | 11.09± 4.22 | 11.85± 3.08 |
| | Nonobstracted kidney | —— | 11.94± 3.45 |

——: Not measured; * : 1 mmHg= 0.133 kPa

2.3 超声结果

实验组术后 1~ 5 d US见梗阻肾肾积水由轻度变为中度, 10 d后发展为重度,梗阻肾呈现一囊状肿块,肾皮质明显变薄,肾体积明显增大,输尿管显著扩张。

RI与 PI高度相关 ($P < 0.001$, $r = 0.96$)。实验组 8例动物输尿管梗阻侧肾 RI升高且明显高于实验前及对照组 RI($P < 0.001$),以 RI≥ 0.58(正常肾 RI$\bar{x}+ 2s$)为判定输尿管梗阻的标准,特异性 99.7%、敏感性 70%。术后 1~ 5 d,梗阻肾 RI处于较高稳定水平,术后 10~ 20 d梗阻肾 RI较术后 1~ 5 d下降 ($P < 0.001$)。对照组双肾 RI实验前后无明显改变 ($P > 0.05$)。梗阻肾 RI与侧健肾 RI差值≥ 0.1,明显高于对照组双肾 RI差值,对照组双肾 RI差异不显著 (差值 < 0.1)。术后 1~ 20 d,实验组对侧健肾 RI较对照组及实验前肾 RI低 ($P < 0.001$)。结果见表 2

表 2 实验组与对照组术前、术后 RI值情况 ($\bar{x}\pm s$)

**Tab 2 RIs of dogs in the control and experiment group before and after operation ($\bar{x}\pm s$)**

| Group | | Pre-operation | Post-operation ($t$ /d) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 5 | 10 | 15 | 20 |
| Experiment | Left kidney* | 0.48± 0.03 | 0.66± 0.04 | 0.66± 0.02 | 0.65± 0.02 | 0.58± 0.04 | 0.58± 0.02 | 0.56± 0.02 |
| | Right kidney | 0.5± 0.01 | 0.44± 0.03 | 0.46± 0.01 | 0.44± 0.02 | 0.45± 0.01 | 0.43± 0.03 | 0.46± 0.02 |
| | ▲ | < 0.1 | > 0.1 | > 0.1 | > 0.1 | > 0.1 | > 0.1 | > 0.1 |
| Control | Left kidney# | 0.49± 0.03 | 0.50± 0.03 | 0.51± 0.02 | 0.49± 0.03 | 0.50± 0.01 | 0.50± 0.03 | 0.49± 0.01 |
| | Right kidney | 0.49± 0.01 | 0.47± 0.06 | 0.49± 0.02 | 0.50± 0.04 | 0.48± 0.02 | 0.48± 0.02 | 0.50± 0.04 |
| | ▲ | < 0.1(0.1) | < 0.1(0.1) | < 0.1(0.1) | < 0.1(0.1) | < 0.1(0.1) | < 0.1(0.1) | < 0.1(0.1) |

▲: Difference in RIs between left and right kidney; * : Ureter ligated; # : Ureter not ligated

## 3 讨论

输尿管梗阻后,肾血管床受影响,肾内动脉收缩,阻力增高[2]。PI RI是反应肾血流动力变化的指数,将 PI RI作为判定输尿管梗阻后肾血流动力改变的指标,消除了声束与血管夹角及血管管径的影响,有较大的可行性。RI与 PI间高度相关,以下仅讨论 RI的变化。

实验组梗阻肾 RI均升高,明显高于术前及对照组肾 RI,以 RI≥ 0.58为判定输尿管梗阻标准,敏感性、特异性均较高,与临床观察结果一致[3~6]。RI升高可能与输尿管梗阻后肾实质缺血水肿压迫肾内动脉有关,也可能与肾素血管紧张素作用有关,本研究病理检查发现梗阻肾肾内动脉管壁增厚,管腔狭窄,可能为引起肾内动脉阻力增高,以至 RI升高的原因,此变化仅局限于梗阻侧肾脏,非梗阻侧肾脏无影响。

Rodger[5]对 10例急性输尿管梗阻追踪观察发现,梗阻后期梗阻肾 RI较急性梗阻时下降; Dodd[6]报道单侧输尿管梗阻家犬的梗阻肾 RI在梗阻后 2~ 4周测值变异较大,认为是受机体循环及环境因素影响的结果[5~7],实验中,我们注意维持动物血流动力状态,使实验结果较稳定,但实验组动物术后 10~ 20 d,梗阻肾 RI较术后 1~ 5 d下降,可能与动物适应了输尿管结扎状态以及手术疼痛消失有关。重要的是影响 RI测值的因素可同时作用于同一动物或人体双侧肾脏,给双侧肾带来相同的影响,若为单侧输尿管梗阻,比较双侧肾 RI差值具有较大意义[1,3~5],本研究发现术后梗阻侧肾 RI明显高于对侧健肾,双侧肾 RI差值≥ 0.1,且显著高于对照组双肾 RI差值 (< 0.1),实验组术后 10~ 20 d, 4例家犬 (11只次)梗阻肾 RI < 0.58,但其双肾 RI差值> 0.1; 1例家犬术后 2 d对侧健肾 RI> 0.58 (RI= 0.603),而梗阻肾 RI明显高于 0.59 (RI= 0.729),双侧肾 RI差值> 0.1,因此,双侧肾 RI差值> 0.1对诊断单侧输尿管梗阻有重要意义。

术后实验组健肾 RI较实验前及对照组降低,与急性实验结果一致[1],有人认为这是输尿管梗阻后健

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侧肾血管阻力代偿性减低的结果,解除梗阻后,这种代偿作用消失,健侧肾 RI可升至正常水平[4]。

梗阻肾 RI不随肾积水程度改变而改变[5],术后 1~ 10 d,梗阻肾积水程度从轻度变化到重度,而梗阻肾 RI维持在较高的稳定水平。

输尿管梗阻 24 h后,梗阻肾肾盂压力升高,梗阻肾 RI维持在较高水平[1],本实验中梗阻后 20 d梗阻肾肾盂压力下降至正常范围,梗阻肾 RI仍处于较高水平,与过去实验证明的输尿管梗阻后期,升高的肾盂压力可恢复至正常范围,但肾内动脉阻力仍可维持在较高水平相一致[2]。

本研究认为,多普勒超声观测输尿管梗阻肾肾内动脉血流动力学改变,输尿管梗阻肾 RI升高,单侧输尿管梗阻梗阻肾 RI与对侧健肾 RI差值≥ 0. 1,对诊断输尿管梗阻有重要意义。

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# Changes of intrarenal arterial hemodynamics after unilateral urinary obstruction in dogs

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**Abstract** Objective: To provide a new method to diagnosis of urinary obstruction through observing the changes of intrarenal arterial hemodynamics after unilateral urinary obstruction in dogs. Methods: Renal ultrasonic examination and intrarenal arterial Doppler examination were performed in 8 dogs with unilateral urinary obstruction and 8 normal dogs before operation and on the 1st to 20th day after operation. The mean intrarenal arterial resistance index (RI) and pulsatility index (PI) of each kidney were calculated and compared with the findings of pathological examination and pelvic pressure measurement. Results: RI and PI were closely correlative ($r$ = 0. 967, $P$ < 0. 001). The mean RI of the obstructed kidney was significantly higher than that in the control ($P$ < 0. 001). The difference of RI between the obstructed kidney and the normal one in the experimental group was significantly higher than that between the two normal kidneys in the control ($P$ < 0. 001). After operation, the RI of the nonobstructed kidney in the experimental group was remarkably lower than that of any kidney in the control ($P$ < 0. 001). RI was not correlated with degrees of hydronephrosis and pelvic pressure. The thickening of the wall and narrowing of cavity of the intrarenal artery in the obstructed kidney caused the elevation of RI. Conclusion: The observation of changes of intrarenal arterial hemodynamics after urinary obstruction with color Doppler ultrasonic examination is of great significance for diagnosis of urinary obstruction.

**Key words** color Doppler ultrasound; urinary obstruction; resistance index; pulsatility index; dog

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