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Impact of ligating gonadal or adrenal collateral veins with the left renal vein on renal function and histology in right-nephrectomized rats

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ABSTRACT

Background: In cases of trauma to the left renal vein (LRV), its ligation near the inferior vena cava (IVC) is considered, but the consequences are not always good. We investigated the role of collateral venous drainage after ligation of the LRV by studying the renal function and histology after ligation of the LRV near the IVC alone or with ligation of the gonadal or adrenal collaterals, in right-nephrectomized (RN) rats.

Material and methods: Ligation of the LRV near the IVC alone (group 1) or with ligation of the adrenal (group 2) or gonadal (group 3) collaterals was studied in RN Wistar rats ($n = 18$ per group). The renal histopathology (ischemic cortical necrosis) and functional status (urea, creatinine, sodium, and potassium) were compared.

Results: In RN rats, the results were better when ligating the LRV near the IVC alone or with the adrenal collaterals [mortality 4/18 (22.2%) and 3/18 (16.7%), respectively] than when ligating the LRV near the IVC plus the gonadal collaterals [mortality 15/18 (83.3%)] ($p < 0.0001$). All early deaths occurred within three days and resulted from serious histopathological (ischemic cortical necrosis) and functional (increased urea, creatinine, and potassium; decreased sodium) renal damage.

Conclusion: In right-nephrectomized rats, the LRV near the IVC and the adrenal collateral can be ligated, while the gonadal collateral should be preserved.

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1. Introduction

Clinical studies have shown that the left renal vein (LRV) may be ligated as part of aortic surgery,[1,2] *en bloc* resection of malignant tumors,[3] iatrogenic artifacts,[4] and in some cases of trauma.[5] The LRV may be ligated safely in close proximity to the inferior vena cava (IVC), but not near the hilum of the kidney.

In general, trauma to veins merits their repair,[6] but this cannot always be performed because of the type and severity of trauma, vital signs and status of the patient, or resources available to the surgical team. In trauma patients who undergo right nephrectomy, the sites of ligation of the LRV and its collaterals are very important and can cause morbidity and mortality,[3] especially when the LRV and one of its collaterals must be ligated.

This study investigated the importance of ligation of the LRV and its collaterals in right-nephrectomized rats, based on the similarity of the renovascular anatomy in humans and rats. We demonstrated that the LRV could be ligated close to the IVC together with ligation of the adrenal collateral, while the gonadal collateral should be preserved.

2. Material and methods

This study was authorized by the Ethics Review Board of our institute and was performed according to the Helsinki Declaration.[7]

Fifty-four 12-week-old Wistar rats of both sexes (250–300 g) were used. They were allowed to acclimatize to their new environment for 1 month before the start of the study. The rats were housed in steel-

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wire cages in rooms at 21 °C and had free access to dry pellet food and water.

The rats were divided randomly into three groups of 18: group 1 (G1), right nephrectomy and ligation of the LRV close to the IVC; group 2 (G2), right nephrectomy and ligation of the LRV close to the IVC plus ligation of the left adrenal vein (Fig. 1); and group 3 (G3), right nephrectomy and ligation of the LRV close to the IVC plus ligation of the left gonadal vein.

The rats were anesthetized by inhalation of diethyl ether. The abdominal skin was shaved and cleaned with povidone-iodide solution. A median laparotomy (length, 3 cm) was performed, followed by a right nephrectomy. The largest collaterals and the left adrenal and gonadal veins were dissected, and the LRV near the IVC was ligated with 5/0 silk. In G1, this constituted the entire procedure. In G2 and G3, the left adrenal and left gonadal veins, respectively, were also ligated with 5/0 silk. Physiological saline (0.9%; 1 cm^3) was injected into the peritoneum after closing the abdomen with a continuous suture of 3/0 silk. Water and food were started on the first postoperative day.

The three groups were further subdivided into groups of six, and the rats were killed on day 7, 15, or 60. Rats were sacrificed after inducing anesthesia with high-dose ethyl ether and drawing intracardiac blood to measure potassium, urea, and creatinine. The left kidneys were removed for histopathological studies. Identical procedures were performed on any rats that died before sacrifice, and blood samples were taken from these rats shortly after death.

The blood was placed in test tubes containing normal gel and centrifuged in a Hettich centrifuge (Hettich, Tuttlingen, Germany) at 3000 rpm for 10 min; the serum obtained was frozen at −70 °C until studied. Serum urea levels were measured using the urease method in a Hitachi Modular P autoanalyzer (Roche Diagnostics, Mannheim, Germany) using a Roche kit (Roche, Basel, Switzerland). Serum creatinine was measured using the same system according to the Jaffe method; serum sodium and potassium were measured with the same system using the ion-selective electrode method.

The kidneys were placed in 10% formaldehyde solution before histopathological examination. The broadest surfaces were analyzed by sectioning through the pelvis in 4-μm-thick slices, which were stained with hematoxylin–eosin. A pathologist who was blind to the study protocol evaluated the renal ischemic cortical necrosis. The extent of (cortical) necrosis was graded from 0 to 3 as follows: 0 (none) = no necrosis; 1 (mild) = necrosis confined to the inner one-third of the cortex, primarily the S3 segment (pars recta) of the proximal tubules; 2 (moderate) = necrosis extending into the upper two-thirds of the cortex; and 3 (severe) = extensive necrosis of all areas of the cortex and necrotic tubules present near the surface of the kidney.[8]

Statistical analyses were carried out using SPSS for Windows ver. 10.0 (SPSS, Chicago, IL, USA). Multiple groups were compared using the Kruskal–Wallis test for non-parametric values and analysis of variance (ANOVA) for parametric values. Two-group comparisons of non-parametric and parametric values were made using the Mann–Whitney *U* test and Tukey test, respectively. Levels of statistical significance were accepted as $p < 0.05$ in two-group comparisons, $p < 0.0167$ in three-group comparisons, and $p < 0.0125$ in four-group comparisons (with the Bonferroni correction).

3. Results

The gonadal vein was larger in caliber than the adrenal vein in all animals at retroperitoneal exploration.

During the laparotomy, after ligating the vessels, some congestion, edema, and cyanosis of the left kidney were observed immediately in all groups. The congestion was most severe in G3, and small hemorrhagic foci were observed in some kidneys in G2 and G3.

After sacrifice with high-dose ethyl ether, the intraperitoneal cavity was observed in all groups, and no other visceral abnormalities were seen. The rats that died prematurely had very edematous, hemorrhagic kidneys on macroscopic examination. The dimensions of the left kidney in rats sacrificed on days 7 and 15 were increased, and the kidneys were swollen and purple in color. The dimensions of the left kidney in rats sacrificed on day 60 were normal or slightly reduced, but the kidneys were partly cyanotic. The unligated branches of the renal vein were dilated in all rats, although no macroscopic thrombi were seen in the LRV or its branches.

There were no abdominal wall problems during wound healing, and no infections were observed in the surviving rats.

There were four (22.2%), three (16.7%), and 15 (83.3%) deaths in G1–G3, respectively. There were significantly more deaths in group G3 (G1 vs. G3: $p < 0.0001$; G2 vs. G3: $p < 0.001$), whereas there was no significant difference between G1 and G2 ($p = 0.67$). The deaths in all groups are shown in Fig. 2. Deaths occurred in the first three postoperative days, and no further deaths were observed until day

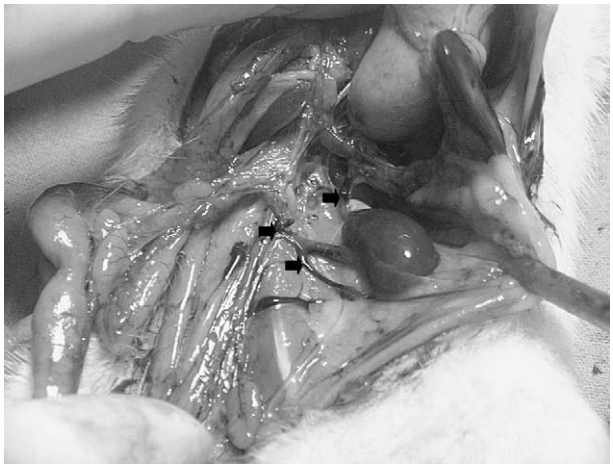

Fig. 1. Demonstration of ligating left renal vein near vena cava and in addition to adrenal collateral. *Upper arrow*: ligated adrenal vein, *middle arrow*: ligated left renal vein, *below arrow*: gonadal vein (group 2; day 7).

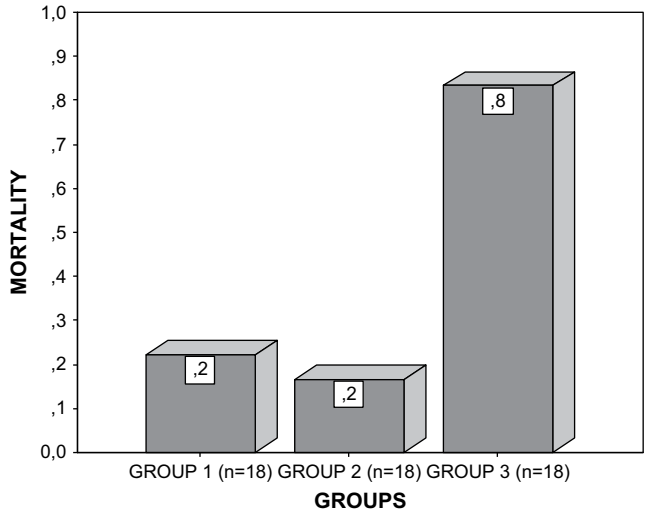

Fig. 2. Mortality rates of groups in the first three days (days 7, 15 and 60).