Use of Bipolar Radiofrequency in Parenchymal Transection of the Liver, Pancreas and Kidney

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Key Words

Bipolar radiofrequency • Habib 4X • Laparoscopic resection • Liver resection • Partial nephrectomy • Distal pancreatectomy

Abstract

Background: Intraoperative blood loss has been shown to be an important factor correlating with increased morbidity and mortality in oncological surgery. Despite technological advances in parenchymal transection devices, bleeding remains the single most important complication. To address this, we designed and developed a bipolar radiofrequency (RF) device, the Habib 4X (Angiodynamics, Inc., Queensbury, N.Y., USA), which was initially used specifically for liver resections. **Methods:** A search using Medline, Embase and Google™ Scholar was performed for the period January 2001 to August 2011. The following Mesh terms were used: 'bipolar radiofrequency', 'Habib 4X', 'laparoscopic', 'liver resection', 'partial nephrectomy' and 'distal pancreatectomy'. The references of the studies included were also reviewed. Series from our centre were excluded. **Results:** There were seven series published, reporting a total of 188 liver resections [113 minor (<3 segments) and 75 major (≥3 segments)] assisted by the bipolar RF (Habib 4X) device over this period. The median blood loss reported ranged from 15 to 427 ml

with a transfusion rate of 0–14%. In addition, five series of partial nephrectomies were also identified, reporting a total of 149 (45 open and 104 laparoscopic) cases. Hilar clamping was not used in any of the cases, and the mean blood loss reported was 100–337 ml whilst the transfusion rate ranged from 0 to 7.1%. There was only one published series of distal pancreatectomies; these were laparoscopic and included 14 patients. **Conclusion:** This review of bipolar RF-assisted liver resections, partial nephrectomies and distal pancreatectomies reported in the literature to date shows that there are significant advantages in using this device in these types of operation.

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Introduction

The first successful liver resection was performed in the early 1700s for a traumatic liver injury, but it was not until 1888 that Langenbuch reported the first elective liver resection [1]. The problem of significant blood loss during the liver parenchymal transection phase of the procedure, however, limited further advances. The 'clamp crush' technique, allowing controlled division of liver parenchyma, was subsequently reported in the 1970s [2]. This method enabled surgeons to ligate blood vessels

Table 1. Liver resections assisted with bipolar RF device

Reference and year	Technique	Resections				Collection abscess	Bile leak	Median blood loss, ml	Trans-fusions	ITU/HDU admission	30-day mortality
		n	Minor	Major	Pringle						
Ferko et al. [37], 2006	H4X	33	19	14	14 (42)	0	0	NS	1 (3)	NS	0
Zacharoulis et al. [38], 2007	H4X	10	8	2	0	0	0	minimal	0	0	0
Sandonato et al. [39], 2009	H4X	22	22	0	NS	1 (4.5)	0	15 (0–40)	1 (4.5)	0	0
Wagman et al. [40], 2009	H4X	76	31	45	20 (26)	5 (6.5)	0	427 (10–2,500)	11 (14)	NS	2 (3)
Curro et al. [41], 2009	RF cool tip/H4X	30	16	14	0	1 (3)	0	30 (10–120)	0	0	0
Taibbi et al. [42], 2011 ^a	H4X	27	27	0	NS	1 (3.7)	0	NS	NS	NS	0
Akyildiz et al. [43], 2011	Laparoscopic H4X	12	12	0	0	0	0	89 ± 77 ^b	0	0	0

Figures in parentheses indicate percentages or range. H4X = Habib 4X; NS = not specified.

^a Includes data from Sandonato et al. [39]. ^b Mean.

and bile ducts during parenchymal transection in a controlled fashion, with or without vascular inflow occlusion (Pringle manoeuvre). In more recent years, several further techniques have been described for the transection of liver parenchyma [3–5]. Despite these advances in surgical technique, liver resection still frequently results in significant blood loss with many patients requiring blood transfusion peri- or postoperatively [6–8]. The main problem with all of these methods is that whilst small vessels can be coagulated during transection, larger vessels are often left patent, resulting in considerable blood loss requiring tedious clipping and suturing in order to achieve haemostasis.

Radiofrequency (RF) devices have been used for more than a decade to thermoablate nonresectable hepatic lesions [9, 10]. We have previously expanded the role of RF to include routine liver resections by using a monopolar RF probe. This allows a plane of coagulative necrosis to be developed along the line of parenchymal transection, with subsequent reduction of blood loss and transfusion [11]. This technique, however, was found to be both time consuming and also carried the risk of skin burns from the grounding pad. To address these problems, we designed and developed a bipolar RF device, the Habib 4X (Angiodynamics, Inc., Queensbury, N.Y., USA). Since its introduction, the device has been used for liver resections, partial nephrectomies and distal pancreatectomies. Here, we present a review of bipolar RF-assisted liver resections, partial nephrectomies and distal pancreatectomies reported in the literature (excluding our centre) with an emphasis on blood loss, blood transfusion and post-operative morbidity and mortality.

Methods

A search using Medline, Embase and Google™ Scholar was performed for the period January 2001 to August 2011 using the Mesh terms ‘bipolar radiofrequency’, ‘Habib 4X’, ‘laparoscopic’, ‘liver resection’, ‘partial nephrectomy’ and ‘distal pancreatectomy’. The ‘related articles’ function was used to broaden the search in PubMed, and references of the studies included were also reviewed. Series from our centre were excluded. The data were analysed with an emphasis on blood loss, blood transfusion and post-operative morbidity and mortality. In series describing liver resections, we also collected data related to bile leaks, intensive care unit/high dependency unit admission, Pringle’s manoeuvre and extent of resection. In series describing partial nephrectomies, specific parameters analysed were hilar clamping, pre- and post-procedure creatinine levels and urinary leaks. In distal pancreatectomies, emphasis was placed on the incidence of pancreatic fistulas.

Results

Liver

Seven published series, excluding case reports and series from our centre, have reported a total of 188 liver resections [113 minor (<3 segments) and 75 major (≥3 segments)] assisted by the bipolar RF (Habib 4X) device over this period. The incidence of post-operative collections requiring intervention ranged from 0 to 6.5%. There were no bile leaks or any episodes of post-operative bleeding. The median blood loss reported ranged from 15 to 427 ml with a transfusion rate of 0–14% (table 1). In addition to these 7 series, Stavrou et al. [12] have reported a liver trisegmentectomy in a patient with colorectal liver metastases using the Habib 4X. The intraoperative blood loss was 100 ml; no blood transfusion was required. The patient developed a collection at the resection margin on

Table 2. Partial nephrectomies assisted with bipolar RF device

Reference and year	Technique	Resections	Hilar clamping	Creatinine before, mg/dl	Creatinine after, mg/dl	Urinary leak	Mean blood loss, ml	Transfusions	30-day mortality
Andonian et al. [44], 2008	Laparoscopic H4X	3	0	1.3	1.4	0	100	0	0
White et al. [45], 2008	H4X	45	0	1.14	1.29	1 (2.2)	133.2	0	0
Nadler et al. [46], 2009	Laparoscopic H4X	16	0	1.03	1.07	0	125 (20–500) ^a	0	0
Wu et al. [47], 2010 ^b	Laparoscopic H4X	42	0	0.99	1.15	7 (16.8)	337	3 (7.1)	0
Bazzi et al. [48], 2011	Laparoscopic H4X	59	0	1.02	1.07	3 (5)	131.4	1 (1.7)	0

Figures in parentheses indicate percentages or range.

^a Median. ^b Includes data from Nadler et al. [46].

day 12 which was successfully drained radiologically to be discharged from hospital on day 21. Dulucq et al. [13] have also reported a redo laparoscopic resection of a recurrent hepatocellular carcinoma (HCC) in an 82-year-old patient with minimal blood loss and good post-operative outcome.

Kidney

Five published series of partial nephrectomies using the Habib 4X were identified, reporting a total of 149 (45 open and 104 laparoscopic) cases (table 2). Hilar clamping was not used in any of the cases, and there was no significant difference in pre- and post-procedure creatinine. The incidence of urinary leaks ranged from 0 to 16.8%. The mean blood loss reported was 100–337 ml, whilst the transfusion rate ranged from 0 to 7.1%. There were no mortalities reported in any of the series.

Pancreas

The only published series of distal pancreatectomies was laparoscopic; this was performed by transecting the pancreas with a Laparoscopic Habib 4X and included 14 patients. There were no conversions to an open procedure, nor were there any blood transfusions, reoperations, or mortalities. The average length of stay was 4.6 days, and only 1 readmission. A clinically significant fistula occurred in 2 patients (14%), only one of which required an intervention.

Discussion

Liver

Indications for liver resection have been continually extended over the past two decades, and currently include performing repeat liver resections for recurrent colorectal

liver metastases [14–16] and HCCs [17, 18], along with major hepatectomies for hilar cholangiocarcinomas [19]. Despite improvement in the safety of liver resections, the procedure is still associated with mortalities and postoperative complications, the most common of which are liver insufficiency, bile leaks and collections [20].

Parenchymal preserving segmental resections are known to significantly improve post-operative outcome [8]. The bipolar RF device (Habib 4X)-assisted technique allows the majority of liver resections to be performed non-anatomically, often limited to less than 3 segments, thus preserving normal liver parenchyma and enabling the possibility of future resections in the event of further metastases. This is particularly important in patients with cirrhosis and chemotherapy-associated steatohepatitis. In addition, appropriate parenchymal-sparing resections have been shown to offer the same long-term benefit as classical lobar resections, but with less risk [21, 22].

The series identified have reported a low rate of blood transfusion (0–14%) in comparison to the majority of published series using other techniques for liver parenchymal transection. Blood transfusion is known to significantly adversely affect post-operative morbidity in patients undergoing liver resection [20, 23] and also adds to the overall cost of the procedure. Resections with minimal blood loss and no transfusion therefore remain the primary objective in hepatobiliary surgery.

Kidney

The increasing widespread use of computerised tomography has led to a dramatic increase in the number of incidentally discovered renal lesions [24]. Open partial nephrectomy is considered to be the gold standard nephron-sparing treatment for renal cell carcinomas [25]. Published data, however, show that partial nephrectomies are used sparingly, mainly because of their atten-

dant risk and technical difficulty [26]. Recent Surveillance, Epidemiology and End Results data suggest that partial nephrectomies are performed in only 11.1%.

Laparoscopic partial nephrectomies are usually performed by clamping the ipsilateral renal vessels, following which the tumour is excised and the nephrotomy repaired. This decreases intraoperative haemorrhage and improves access to the renal-collecting system for repair. Even for the most experienced laparoscopic renal surgeons, ischaemic time is 50% longer than that of open surgery, and hypothermia is rarely performed [27]. New data indicate that even a short interval of warm ischaemia can significantly increase the risk of acute renal failure and chronic renal insufficiency [28]. Margin-free excision of the tumour followed by haemostasis and closure of the collecting system must be performed in <30 min to avoid irreversible warm ischaemic renal damage [29]. Hilar clamping was not used in any of the 5 series using the Habib 4X identified. All reported no significant difference in pre- and post-procedure creatinine, whilst urinary leaks, blood loss and transfusion rates were all low. These data demonstrate that non-ischaemic partial nephrectomies using the Habib 4X are not only feasible, but have a similar safety profile to established techniques and do not compromise oncological outcomes.

Pancreas

In both open distal pancreatectomies and laparoscopic distal pancreatectomies (LDP), the pancreatic remnant remains a significant source of morbidity. Rates of pancreatic fistulas range from 16 to 30%, and the rates of those that require intervention range from 7 to 22% [30–34]. If these measures fail, the eventual reoperation rates for LDP are reported to be between 5 and 20% [30, 32]. These results suggest that postoperative pancreatic fistulas remain problematic after distal pancreatectomies, whether performed as an open procedure or laparoscopically. Previous laparoscopic series have relied heavily on the endoscopic stapler for pancreatic transection [31, 32, 34, 35]. Fronza et al. [36] have recently published the first series of LDPs performed transecting the pancreas with a Laparoscopic Habib 4X, with a pancreatic fistula rate of 14% (n = 2/14).

In conclusion, this review of bipolar RF-assisted liver resections, partial nephrectomies and distal pancreatectomies reported in the literature to date shows that there are significant advantages in using this device in these types of operation.

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