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Rubber tourniquet technique: A simple, safe, and cost-effective method of hepatic resection in neonates and infants

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Abstract

Background

Despite the improvements in [patient care](#), understanding of surgical anatomy of liver and [surgical techniques](#), [liver resection](#) is a high-risk procedure specifically in infants and neonates; whose blood volume is limited (80 ml/kg). This report shares the experience of hepatic resection with “Rubber tourniquet technique” in patients less than 6-months of age.

Methods

Hepatic resection in a 4-month-old pair of [Conjoined twins](#) with shared liver and a 3-day old baby with large Congenital [Hepatoblastoma](#) was performed using Penrose rubber drain as a tourniquet around the [liver parenchyma](#) to reduce blood loss.

Results

Blood loss was minimal (< 20CC) and all the three babies survived the procedure without complications.

Conclusion

Rubber tourniquet technique is simple, safe and cost-effective for liver resections in neonates and infants with [hepatic lesions](#) and separation of conjoined twins with shared liver and it can easily be employed in resource constraint settings.

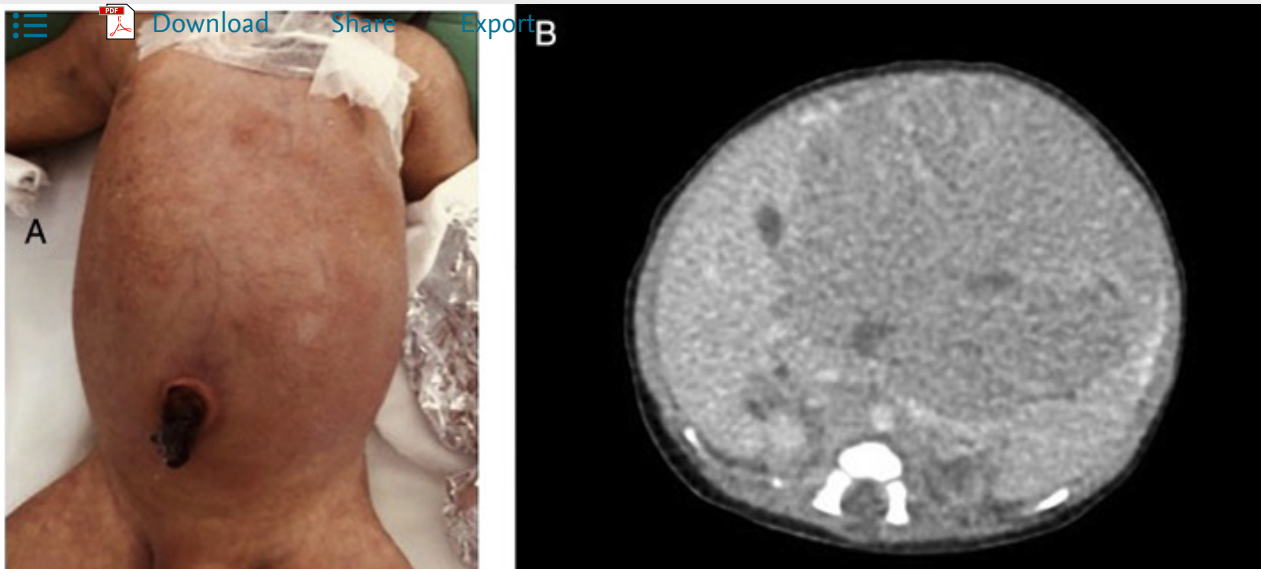
Key words

Hepatic resections is a high-risk procedure performed in **pediatric surgery** practice for tumors e.g. **hepatoblastoma**, trauma and rarely in separation of **conjoined twins** [1], [2]. Understanding of anatomy of liver, improvement in anesthesia, intensive care and **surgical techniques** exploiting technological advances e.g. Cavitron ultrasonic aspirator, water jet dissector etc., has helped to perform liver resections with low **morbidity** and mortality [3], [4], [5]. However, a recent Cochrane review suggest that these high-tech utilities do not seems to have reduced intraoperative bleeding when compared to the time tested clamp-crush technique [6]. Moreover, these devices may not be accessible to surgeons working in low- and mid-income countries, where hepatic resections in children (both anatomical and non-anatomical) continues to be a challenge and carries a high morbidity and mortality and such procedures are often refused. In such situations, the Pledged **suturing** and Cotton Tourniquet techniques as reported by Sandler et al. and Yang et al. seems to be promising [7], [8].

Purpose of this report is to share the experience of **hepatic resection** in three patients less than 6-months of age using Rubber tourniquet technique.

1. Case 1

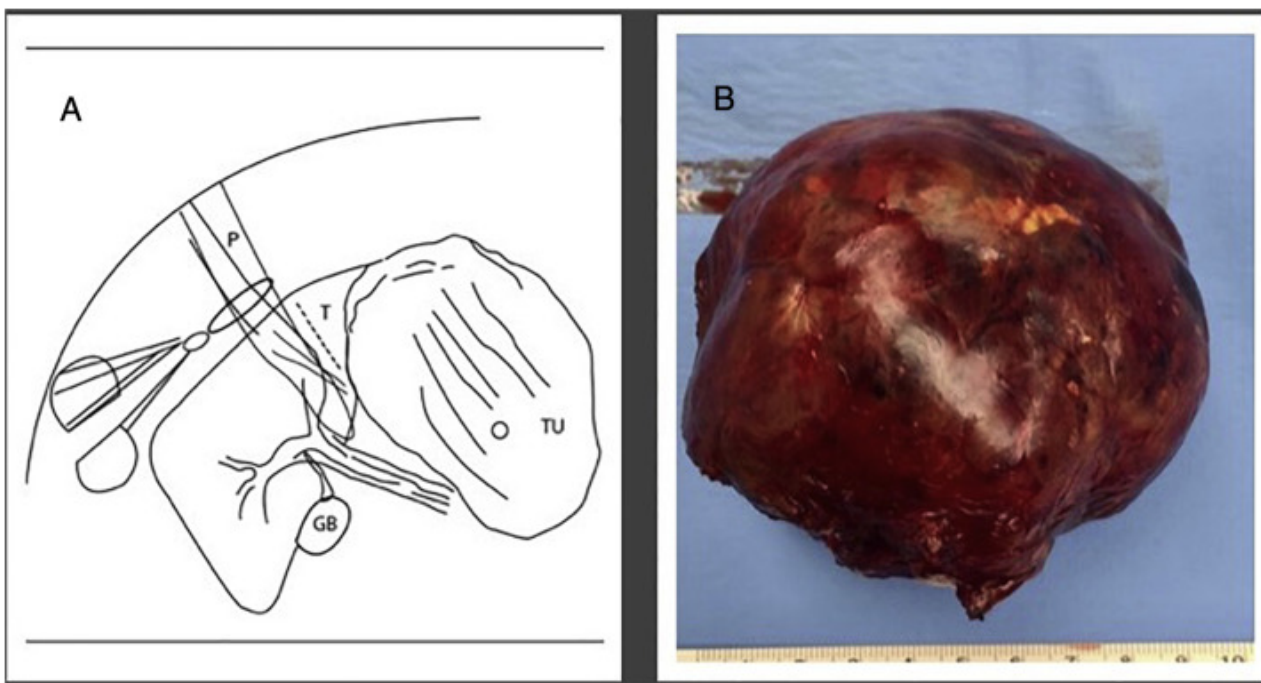
A 3-day-old baby was transfer to **Neonatal Intensive Care** unit (NICU) with **abdominal distension**. He was born to a primigravida after a full-term pregnancy and delivery. A pre-natal ultrasound scan (US) at 34 weeks revealed a complex upper-abdominal mass. Hemoglobin and **Hematocrit** was 14.3g/dl and 44.3 respectively. Platelets, differential **leucocyte** count (DLC), PT, APTT, INR, **C-Reactive Proteins** (CRP) levels, serum electrolytes, **creatinine** and **liver function tests** including serum **bilirubin** were normal for the age. Alpha-Fetoproteins (2.4 million U/ml) were very high for the age [9]. Examination revealed a large **abdominal mass** occupying 2/3 of abdomen (**Fig. 1**). An US and Doppler scan revealed a hyperechoic and vascular mass arising from Liver. A contrast enhanced **CT scan** of chest and abdomen revealed normal lungs and a 10×8 cm solid mass with cystic areas arising from segment II and III of left lobe of liver (**Fig. 1**). On third day of admission, hemoglobin dropped to 8.5g/dl and he required transfusion of blood products and elective ventilation due to progressive abdominal distension and **respiratory distress**. With diagnosis of hemorrhage in **liver tumor** (Hepatoblastoma), baby was moved to **operating room**. Abdomen exploration through supraumbilical transverse **incision** revealed 10 × 8cm pedunculated **vascular tumor** originating form II and III segments of left lobe (**Fig. 2**). The liver was mobilized by division of falciform, left triangular and coronary **ligaments** from its bed and an 18"X 0.25" Penrose rubber drain^R (*Bard Medical Division, Covington30014, GA*) was passed around the liver pushing it as close as possible to **inferior vena cava** and tied gently about 2.0 cm from the tumor margin (**Fig. 2**). Tying a knot to the drain, slight lateral **traction**, and notch between right and left anatomical lobes helped to keep the drain in place. The liver was divided with Bipolar **diathermy** (*Velleylab, Boulder, CO, US*). Large vessels and ducts were suture ligated with 5/0 Vicryl^R and liver surface with sprayed with **Fibrin glue** (*Tisseel, Baxter Corporation, Ontario, Canada*) to ensure **hemostasis**. Blood loss was less than 20 CC. **Post-operative recovery** was uneventful, and histology revealed fetal variety of **Hepatoblastoma**. **Resection margins** were tumor free and alpha-fetoprotein level dropped to normal for the age within a month. Chemotherapy was proposed but it was refused by the family. Patient is on monthly follow up (clinical examination, US of liver, and alpha-fetoproteins levels). At 6-months of age, patient is thriving, alpha fetoproteins are within normal range and a recent CT scan of chest and abdomen did showed evidence of **recurrence** or **metastasis**.



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Fig. 1. A) **Abdominal distension** in 3-day old with; B) **Hepatoblastoma** involving segment II and III of liver.



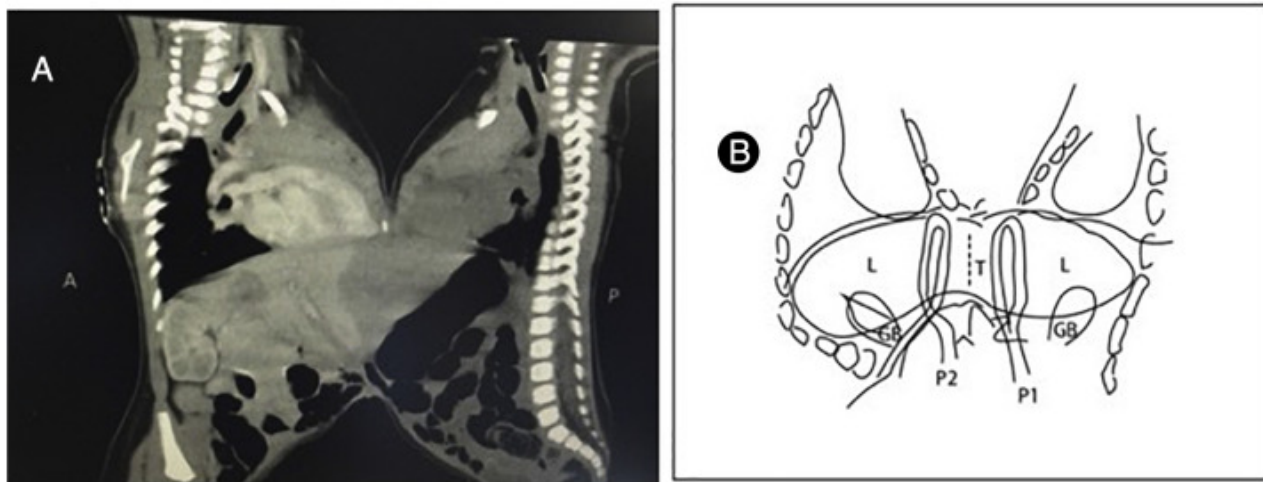
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Fig. 2. A) Illustration showing “Rubber Tourniquet Technique”- P, **Penrose drain** as tourniquet around the left lobe of liver, T, **Transection line**, (TU) **Tumor**, B) **Resected Hepatoblastoma**.

2. Case 2

month old. At presentation combined weight was 9.1 kg and one twin had **Tetralogy of Fallot** (Pink TOF). Fusion extended from lower chest to **umbilicus**. Preoperative imaging revealed a common **pericardium** with two independent hearts and no flow of contrast across the midline (**Fig. 3**). Right and left lobes of livers were fused but there were two independent set of biliary, gastrointestinal and **genitourinary tracts**. Liver fusion was 5 cm long and 4.5 cm thick. Guided by contrast enhanced **CT scan** and intraoperative findings, transection line was marked between the two **gallbladders** and **bile ducts**. Two 18"×0.25" Penrose drains^R (*Bard Medical Division, Covington30014, GA*) passed and knotted around the fused liver; 2 cm lateral to the marked transection line (**Fig. 3**). We preferred rubber drain over cotton straps as these are readily available in operating in sterilized packing, stretchable, easy to secure and pressure on the liver can be regulate according to its texture. The liver was transected with Bipolar **diathermy** (*Velleylab, Boulder, CO, US*). Large **blood vessels** and bile ducts were suture ligated with 5/0 vicryl^R (*Ethicon*). Using this maneuver, we were able to transect the liver with minimal blood loss (< 20CC). The raw area of the livers was sprayed with **fibrin glue** to ensure **hemostasis** (*Tisseel, Baxter Corporation, Ontario, Canada*). Both babies were discharged from hospital on 14th postoperative day. Twin with Pink TOF had the anomaly corrected after a year of separation. Currently both the twins are living independently without any substantial medical support, go to school and maintain normal growth parameters on more than 4years of regular follow up.






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Fig. 3. A) Contrast enhanced **CT Scan** showing extent of fusion including shared liver, B) Illustration showing **Penrose drains** P1 and P 2 as tourniquets around the fused liver(L) and transection line(T) between the **Gallbladders** (GB).

3. Discussion

Hepatoblastoma is a common malignant **liver tumor** in children and most cases are reported between 2 and 5 years of age [1], [10]. It is rare in first three month of life and is classified as Congenital Hepatoblastoma. Less than 60 cases are reported in literature [11]. Contrary to previous belief it is suggested that these patients should be managed like other patients with hepatoblastoma with surgery and chemotherapy [12]. Similarly, **Conjoined twins** are rare (Reported incidence 1:250,000) but cases are frequently highlighted in literature, social and electronic media [2].

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months unique surgical challenges, as excessive **hemorrhage and hypovolemic shock** can occur due to limited blood volume (80 ml/kg) [7]. Moreover, at this age liver is fragile, thin Glisson's capsule may not endure **suturing** and is prone to **ischemia–reperfusion injury** with its associated **hemodynamic** and metabolic consequences even after a brief total hepatic vascular isolation [13]. In such a situation, pledged suturing and cotton tourniquet techniques are promising, as these can be applied promptly to control inter-operative bleeding in selected cases of hepatic tumors in children and in emergency e.g. ruptured **liver tumors and trauma**. We consider the technique, a modification of above-mentioned techniques and liver hanging maneuver reported by Belghiti et al. [14], [15] It is simple, effective and easily reproducible to control hemorrhage during **hepatic resections** in resource limited settings. Penrose drains^R are easily available in most **operating rooms**, pressure can be adjusted without fracturing the fragile livers of young patient, keep surgeon oriented to marked level of resection and it allows enough time to employ other methods of **hemostasis** e.g. **fibrin glue**, bipolar **diathermy** coagulation and suture **ligation** of large vessels. However, it is applicable to a selected group of patients as drain can slip off if the **resection margin** is too close to the drain.

In conclusion, a simple, safe and cost-effective method of liver resection is reported which can be utilized in selected cases of hepatic lesion in neonates, infants and children, and separation of conjoined twins with shared liver. It can easily be employed in resource constraint settings to advance global surgery agenda.

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