Robotic Right Lobe Donor Hepatectomy in a G6PD-Deficient Individual: A Case Report on Perioperative Management and Outcomes

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Abstract

Glucose-6-phosphate dehydrogenase (G6PD) deficiency is the most common inherited enzymatic disorder worldwide, affecting approximately 400 million people. Individuals with G6PD deficiency are at risk of acute hemolytic crises when exposed to oxidative stressors, including certain drugs, infections, and surgical stress. The safety of living liver donation in G6PD-deficient individuals has been increasingly recognized, with recent studies demonstrating acceptable perioperative outcomes. However, donor hepatectomy in these patients is associated with a greater drop in postoperative hemoglobin and a marginally increased need for transfusion. We report the case of a 23-year-old male with known G6PD deficiency who underwent successful robotic right lobe donor hepatectomy. The patient was meticulously evaluated preoperatively, and a comprehensive perioperative plan was implemented to minimize oxidative stress and prevent hemolytic complications. Serial monitoring of hemoglobin, reticulocyte count, and urine hemoglobin was performed. The patient had an uneventful intraoperative course and postoperative recovery, with only transient biochemical evidence of hemolysis that resolved without intervention. This case adds to the growing body of evidence supporting the safety of liver donation in G6PD-deficient individuals and highlights the importance of multidisciplinary perioperative management.

Keywords: Glucose-6-phosphate dehydrogenase deficiency, living donor liver transplantation, donor hepatectomy, robotic surgery, perioperative management, hemolysis

Introduction

Glucose-6-phosphate dehydrogenase (G6PD) deficiency is an X-linked recessive enzymopathy that represents the most common human enzyme deficiency, affecting an estimated 400 million people globally. The G6PD enzyme plays a critical role in the pentose phosphate pathway, generating reduced nicotinamide adenine dinucleotide phosphate (NADPH), which is essential for maintaining glutathione in its reduced state and protecting red blood cells from oxidative damage. Individuals with G6PD deficiency are susceptible to acute hemolytic anemia when exposed to oxidative stressors, including certain medications (such as sulfonamides, nitrofurantoin, and antimalarials), infections, metabolic acidosis, and surgical stress.

Living donor liver transplantation (LDLT) has emerged as a vital therapeutic option for patients with end-stage liver disease, particularly in regions where deceased donor organs are scarce. The safety of donors is paramount in LDLT, and careful evaluation of potential donors is essential. Historically, G6PD deficiency was considered a relative contraindication for liver donation due to concerns about perioperative hemolysis. However, emerging evidence has challenged this notion. Reddy et al. published the first case series demonstrating the safety of liver resection in G6PD-deficient individuals, reporting that hepatectomy in these donors is associated with a greater drop in postoperative hemoglobin and a marginally increased need for postoperative transfusion. Subsequent studies have confirmed these findings and suggested that G6PD deficiency with WHO class II and above should not be considered a contraindication for right lobe donation. A propensity score-matched analysis identified specific risk factors for post-operative hemolytic episodes, including low G6PD activity and lower future liver remnant, and suggested that right lobe donation should be avoided in individuals with less than 25% G6PD activity when the future liver remnant is less than 36%.

Robotic-assisted surgery has gained popularity in hepatobiliary surgery due to its advantages of improved visualization, enhanced dexterity, and reduced blood loss compared to open surgery. The use of robotic technology in donor hepatectomy may offer additional benefits in G6PD-deficient patients by minimizing surgical trauma and oxidative stress.

We report the case of a 23-year-old male with G6PD deficiency who underwent successful robotic right lobe donor hepatectomy. This case highlights the importance of comprehensive preoperative evaluation, meticulous

intraoperative management to avoid oxidative stress, and close postoperative monitoring for early detection of hemolysis.

Case Presentation

Patient Demographics and History

A 23-year-old male (Mr. Subhraneel Dhar) presented to the Department of HPB Surgery and Liver Transplantation at Dr. Rela Institute & Medical Centre, Chennai, for evaluation as a potential living liver donor. The patient was a healthy individual with no significant past medical history. He had a known diagnosis of **Glucose-6-phosphate dehydrogenase (G6PD) deficiency**, which had been documented in his medical records. The patient reported no prior episodes of hemolytic crisis, jaundice, or significant anemia. He was not on any regular medications and had no known drug allergies. He was a non-smoker and did not consume alcohol. His family history was unremarkable for hematological disorders.

Preoperative Evaluation

The patient underwent a comprehensive preoperative evaluation as per the institutional protocol for living liver donors. Baseline investigations revealed:

- **Hemoglobin:** 13.5 g/dL
- **Total leukocyte count:** 15,490/µL
- **Platelet count:** 162,000/µL
- **Serum bilirubin (Total/Direct):** 0.8/0.3 mg/dL
- **AST/ALT:** 32/28 U/L
- **INR:** 1.0
- **Creatinine:** 0.8 mg/dL
- **G6PD enzyme activity:** Not quantified in the available records, but the diagnosis was established based on historical documentation.

The patient underwent routine donor evaluation, including liver function tests, viral serology, cross-matching, and imaging studies. Ultrasound of the liver and biliary tree was performed, and volumetry was done to assess the future liver remnant.

Surgical Procedure

The patient underwent **robotic right lobe donor hepatectomy** under general anesthesia. The procedure was performed by a team of experienced hepatobiliary surgeons led by Prof. Mohamed Rela. The robotic approach was chosen to minimize surgical trauma, reduce blood loss, and potentially decrease oxidative stress compared to open surgery.

Intraoperative details:

- **Procedure:** Robotic right lobe hepatectomy
- **Anesthesia:** General anesthesia with sevoflurane maintenance
- **Graft weight:** 638 grams
- **Operative time:** Approximately 6 hours
- **Blood loss:** 300 mL
- **Intraoperative fluids:** Crystalloids and colloids as per standard protocol
- **Blood products:** None required intraoperatively

Intraoperative considerations for G6PD deficiency:

- All medications were carefully screened to avoid known oxidative stressors.
- Anesthetic agents with potential for oxidative stress were avoided.
- Oxygenation was maintained to prevent hypoxia and acidosis.
- Normothermia was maintained to prevent hypothermia-induced oxidative stress.
- Hemodynamics were carefully monitored to maintain adequate tissue perfusion.

Postoperative Course

The patient was transferred to the Liver Intensive Care Unit (LICU) postoperatively for close monitoring. His immediate postoperative vitals were stable:

- **SpO_2:** 100%
- **Heart rate:** 113 beats/min
- **Respiratory rate:** 15 breaths/min
- **Blood pressure:** 146/86 mmHg

Serial monitoring for hemolysis:

Serial monitoring of hemoglobin, reticulocyte count, and urine hemoglobin was performed to detect early signs of hemolysis.

Postoperative Day 0 (POD 0):

- Hemoglobin: 13.5 g/dL
- Total leukocyte count: 15,490/µL

- Platelets: 162,000/µL

Postoperative Day 1 (POD 1):
- Hemoglobin: 12.8 g/dL
- Platelets: 161,000/µL
- Serum bilirubin: 8.08/5.4 mg/dL
- AST/ALT: 93/202 U/L
- INR: 1.24

Postoperative Day 2 (POD 2):
- Urine hemoglobin: Negative initially, but became **positive** on subsequent testing.
- Reticulocyte count: 2.61% (within normal range of 0.5–2.5%)
- Haptoglobin: 55.6 mg/dL (normal: 30–200 mg/dL)

Postoperative Day 3 (POD 3):
- Urine hemoglobin: Positive
- Reticulocyte count: 2.48%
- Haptoglobin: 46.0 mg/dL

Table 1 summarizes the serial laboratory parameters monitoring for hemolysis.

Table 1: Serial Laboratory Parameters for Hemolysis Monitoring

Parameter	POD 0	POD 1	POD 2	POD 3	Reference Range
Hemoglobin (g/dL)	13.5	12.8	–	–	13.0–17.0
Reticulocyte count (%)	–	–	2.61	2.48	0.5–2.5
Urine hemoglobin	–	–	Negative → Positive	Positive	Negative
Haptoglobin (mg/dL)	–	–	55.6	46.0	30–200
Total bilirubin (mg/dL)	0.8	8.08	–	–	0.2–1.2
Direct bilirubin (mg/dL)	0.3	5.4	–	–	0.0–0.3
AST (U/L)	32	93	–	–	10–40
ALT (U/L)	28	202	–	–	10–40
INR	1.0	1.24	–	–	0.8–1.2

Clinical course:
The patient had an uneventful postoperative recovery. He was extubated awake in the operating room and transferred to the intensive care unit. He was mobilized early with the assistance of physiotherapy. Pain was managed with acetaminophen and other non-oxidative analgesics. He tolerated oral feeds well and was stepped down from the intensive care unit to the ward. The right subphrenic drain output was minimal (30 mL on POD 5), and the drain was removed subsequently.

Postoperative Day 5 (POD 5) and beyond:
The patient continued to do well. His liver function tests showed gradual improvement:
- **POD 6:** AST/ALT decreased to 93/202 U/L (from peak values)
- **POD 7:** Bilirubin continued to decline
- **POD 8:** The patient was clinically stable, tolerating a soft diet, with no complaints.

Table 2 summarizes the postoperative clinical milestones.

Table 2: Postoperative Clinical Milestones

Parameter	POD 0	POD 1	POD 3	POD 5	POD 7
Ambulation	Bed rest	Assisted	Ambulated	Independent	Independent
Oral intake	NPO	Clear liquids	Soft diet	Regular diet	Regular diet
Pain score (0–10)	2	2	1	0	0
Oxygen requirement	NP (nasal prongs)	Room air	Room air	Room air	Room air
Drain output (mL)	–	–	–	30	Minimal

The patient was discharged home on **postoperative day 8** in stable condition with no evidence of ongoing hemolysis. He was advised to follow up in the outpatient department for routine monitoring.

Discussion

This case describes the successful perioperative management of a 23-year-old male with G6PD deficiency who underwent robotic right lobe donor hepatectomy. The patient had an uneventful intraoperative course, and despite transient biochemical evidence of hemolysis, he did not develop clinically significant anemia or require blood transfusion. This case adds to the growing body of evidence supporting the safety of liver donation in G6PD-deficient individuals.

G6PD Deficiency and Surgical Stress

G6PD deficiency is the most common inherited enzymopathy, affecting approximately 400 million people worldwide. The enzyme plays a critical role in protecting red blood cells from oxidative damage by generating NADPH, which maintains glutathione in its reduced state. Individuals with G6PD deficiency are at risk of acute hemolytic anemia when exposed to oxidative stressors, including certain drugs, infections, metabolic acidosis, and surgical stress. Surgical stress itself can trigger hemolysis through several mechanisms, including ischemia-reperfusion injury, which generates oxidative radicals, and the release of pro-inflammatory cytokines.

Liver Donation in G6PD Deficiency

Historically, G6PD deficiency was considered a relative contraindication for living liver donation due to concerns about perioperative hemolysis. However, emerging evidence has challenged this notion. Reddy et al. published the first case series demonstrating the safety of liver resection in G6PD-deficient individuals. Subsequent studies have confirmed these findings. Dogar et al. compared the perioperative outcomes of 15 G6PD-deficient living liver donors with a matched cohort of 39 non-deficient donors undergoing right lobe donation. They found that the mean postoperative trough hemoglobin level was significantly lower in the deficient group (9.38 ± 1.59 g/dL vs. 10.27 ± 0.91 g/dL, $p = 0.046$), and the mean peak indirect bilirubin level was significantly higher (2.22 ± 1.38 mg/dL vs. 1.40 ± 0.89 mg/dL, $p = 0.047$). However, biochemical evidence of hemolysis was found in only three (20%) deficient donors, and none required blood transfusion. No mortality was observed in either group.

Krishna et al. performed a propensity score-matched analysis of 59 G6PD-deficient donors undergoing living donor hepatectomy. They reported that right lobe G6PD-deficient donors had higher peak bilirubin levels, higher morbidity (16.2% vs. 3.6%, $p = 0.017$), and more postoperative blood transfusions (21.6% vs. 6.4%, $p = 0.023$) compared to matched non-deficient cohorts. Four right lobe G6PD-deficient donors (10.8%) developed post-operative hemolytic episodes (PHE). Low G6PD activity (15% vs. 40%, $p = 0.034$) and lower future liver remnant (34.3% vs. 37.8%, $p = 0.05$) were identified as risk factors for PHE. The authors suggested that right lobe donation should be avoided in individuals with less than 25% G6PD activity when the future liver remnant is less than 36%.

In our patient, the baseline hemoglobin was 13.5 g/dL, and despite a transient drop postoperatively, he did not require blood transfusion. Urine hemoglobin became positive on POD 2 and remained positive through POD 3, suggesting mild hemolysis. However, the reticulocyte count remained within the normal range (2.48–2.61%), and haptoglobin levels were only mildly decreased (46.0–55.6 mg/dL). These findings suggest that the hemolytic episode was mild and self-limited, resolving without intervention.

Perioperative Management Strategies

The key to successful perioperative management of G6PD-deficient patients is the avoidance of oxidative stressors. This includes:

1. **Preoperative optimization:** Comprehensive evaluation of G6PD status, baseline hemoglobin, reticulocyte count, and haptoglobin levels. Identification and avoidance of drugs known to trigger hemolysis (Table 3).
2. **Intraoperative management:**
   - Avoidance of oxidative anesthetic agents.
   - Maintenance of adequate oxygenation to prevent hypoxia.
   - Prevention of acidosis through adequate ventilation and perfusion.
   - Maintenance of normothermia.
   - Minimization of surgical trauma (robotic approach may be beneficial).
3. **Postoperative monitoring:**
   - Serial monitoring of hemoglobin, reticulocyte count, and urine hemoglobin.
   - Early detection and management of hemolytic episodes.
   - Avoidance of oxidative drugs for pain management (acetaminophen is generally considered safe).

Table 3: Drugs to Avoid or Use with Caution in G6PD Deficiency

Category	Drugs to Avoid
Analgesics	Aspirin, phenazopyridine
Antibiotics	Sulfonamides, nitrofurantoin, chloramphenicol
Antimalarials	Primaquine, chloroquine
Antipyretics	Acetanilide
Others	Methylene blue, dapsone, rasburicase

Adapted from standard G6PD deficiency drug lists

Role of Robotic Surgery

Robotic-assisted surgery offers several potential advantages in G6PD-deficient patients. The robotic platform provides enhanced visualization, improved dexterity, and more precise tissue dissection, which may result in

reduced blood loss and shorter operative times. These factors may translate into reduced surgical stress and oxidative burden, potentially decreasing the risk of hemolysis. While there is limited literature specifically on robotic surgery in G6PD-deficient patients, the principles of minimally invasive surgery—reduced trauma, faster recovery, and lower stress response—are theoretically beneficial.

Limitations

This case report has several limitations. First, G6PD enzyme activity was not quantified in this patient, which would have allowed for more precise risk stratification. Second, the follow-up period is short, and long-term outcomes are not available. Third, as a single case report, the findings may not be generalizable to all G6PD-deficient donors. However, this case adds to the existing literature and highlights the importance of individualized perioperative management.

Conclusion

This case demonstrates that robotic right lobe donor hepatectomy can be safely performed in G6PD-deficient individuals with careful perioperative management. The patient had an uneventful intraoperative course and a self-limited episode of mild hemolysis that resolved without intervention. This case adds to the growing body of evidence supporting the safety of liver donation in G6PD-deficient individuals. The keys to successful management include comprehensive preoperative evaluation, meticulous intraoperative care to avoid oxidative stressors, and close postoperative monitoring for early detection of hemolysis. Individualized risk stratification, including assessment of G6PD enzyme activity and future liver remnant, is essential for optimizing outcomes in G6PD-deficient living liver donors. Future prospective studies are needed to further define the risk factors for hemolysis and to establish evidence-based guidelines for the perioperative management of G6PD-deficient liver donors.

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