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CASE REPORT

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Unveiling the hidden risk: a case of severe jaundice triggered by intra-aortic balloon pump after cardiac surgery

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Abstract

Background The Intra-Aortic Balloon Pump (IABP) is a widely utilized technique to provide circulatory support for critically ill patients with cardiac dysfunction. While IABP therapy offers clinical benefits, the placement of an IABP catheter can potentially lead to a range of complications in certain high-risk patients. This case report presents a rare instance of progressive jaundice associated with IABP implantation.

Case presentation The patient was a 56-year-old female who had undergone cardiac valve surgery due to rheumatic combined valve disease. She subsequently developed postoperative low cardiac output syndrome, necessitating the implementation of IABP support. However, the patient exhibited a rapid deterioration in jaundice, coupled with aberrant liver function and suspicion of concurrent pancreatitis. Further thoracoabdominal computed tomography (CT) examinations revealed that when the IABP balloon was fully inflated, the aorta was completely occluded. The diagnosis of hepatic impairment was suspected to likely result from a reduced hepatic blood flow caused by obstruction of the celiac trunk related to the occlusive IABP balloon. Therefore, the IABP was removed, leading to a gradual amelioration of jaundice symptoms as well as bilirubin levels.

Conclusions This case advocates a reevaluation of the strategy for selecting the size of the IABP balloon, particularly in high-risk patient populations. A marginally smaller balloon size may be warranted to mitigate the risk of vascular-related complications. In cases presenting with progressive jaundice and hepatic impairment following IABP insertion, proactive imaging studies should be promptly conducted to ascertain their correlation with the IABP placement. If there is suspicion of visceral ischemia associated with the IABP balloon, immediate removal of the device should be undertaken to prevent irreversible adverse events.

Keywords Intra-aortic balloon pump, Cardiac surgery, Hepatic dysfunction, Jaundice

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Background

The intra-aortic balloon pump (IABP) is a widely utilized circulatory support device in critically ill patients with compromised cardiac function. Despite its clinical benefits, the placement of the balloon can result in various complications, notably vascular issues like lower limb ischemia, mesenteric ischemia, and vascular injuries [1]. Lower limb ischemia stands out as the frequently reported complication, contrasting with the relatively low occurrence of visceral ischemia, a domain with limited associated research. This scarcity of literature on visceral ischemia may stem from the vague symptoms, often overshadowed by gastrointestinal dysfunction arising from heart failure. Severe liver damage, on the other hand, is an infrequent adverse outcome associated with IABP use. Here, we describe a unique clinical case where progressive jaundice, linked to the placement of an IABP, was swiftly resolved upon the timely removal of the device.

Case presentation

The patient was a 56-year-old female, measuring 156 cm in height and weighing 45.8 kg, who was admitted due to a history of "recurring dyspnea on exertion spanning over 7 years". She had no significant prior medical history. Two weeks prior to admission, echocardiography revealed rheumatic heart disease, with severe mitral valve stenosis (mitral valve area 0.9 cm^2) and severe regurgitation (regurgitant area 10.4 cm^2), mild aortic valve regurgitation, severe tricuspid regurgitation (regurgitant area 16.0 cm^2), and a small pericardial effusion. The left ventricular ejection fraction (LVEF) was observed to be 68%. The right ventricular fractional area change (RAFAC) was 40%, with a tricuspid annular M-mode displacement of 22 mm and a tricuspid annular right ventricular wall tissue velocity of 13 cm/s. Preoperative assessments indicated normal liver and kidney function, with no evidence of significant coronary artery stenosis on coronary angiography.

The patient underwent valve surgery, specifically mitral valve mechanical replacement (St. Jude MV 27 mm), tricuspid valve repair (Edwards MC3 30#), and left atrial appendage closure. The cardiopulmonary bypass (CPB) duration was 90 min, with an aortic cross-clamp (ACC) time of 52 min. DEL Nido cardioplegia solution was administered at 3 min of aortic cross-clamping, with a volume of 1000 ml, delivered through antegrade needle injection directly into the ascending aorta. A single infusion was utilized due to the short duration of the aortic cross-clamping period. On the night after the operation (day 0), the patient presented with hypotension, tachycardia, oliguria, elevated lactate levels. Bedside echocardiographic evaluation revealed left ventricular enlargement, spherical expansion at the apex with diffuse reduction in systolic activity, resulting in an LVEF of 30%. The mitral valve function was normal, with mild to moderate tricuspid regurgitation. Right ventricular systolic function was adequate, with a RVFAC of 35%. Following this, a Swan-Ganz catheter was inserted, which measured a pulmonary artery pressure of approximately 35/20 mmHg, a pulmonary capillary wedge pressure (PCWP) of 23 mmHg, and a cardiac output (CO) of 1.5 L/min/m^2 (Table 1). In addition, postoperative monitoring of electrocardiograms, cardiac enzyme profiles, and troponin levels ruled out coronary artery occlusion. Therefore, the patient was suspected to have developed low cardiac output syndrome. Despite adjustments in medication and fluid volume, the patient's blood pressure remained low, with a central venous pressure (CVP) of 15–18 mmHg, persistently elevated pulmonary capillary wedge pressure (PCWP) above 20 mmHg, urine output less than 0.5 ml/kg/h, vasoactive-inotropic score (VIS) of 20, and indications of hepatic and renal dysfunction associated with low cardiac output [total bilirubin (TB) 52.6 μmol/L, direct bilirubin (DB) 18.6 μmol/L, alanine aminotransferase (ALT) 85 U/L, aspartate transaminase (AST) 194 U/L, creatinine 159 μmol/L). Consequently, the decision was made to initiate IABP assistance on day 1.

Table 1 Postoperative hemodynamic parameters and cardiac ultrasound results

Post-op Date	CVP (mmHg)	PCWP (mmHg)	CO (L/min)	CI (L/min/m^2)	SVR (dyn·sec/cm^5)	VIS max	Ultrasound	
							LVEF (%)	RVFAC (%)
0	18	23	2.2	1.5	2170	30	35%	36%
1	16	22	2.5	1.7	1984	20		
2	12	16	2.9	2.0	1876	15		
3	11	14	3.0	2.1	2036	10		
4	11	13	3.3	2.3	1892	5	40%	38%
5	8	10	3.5	2.4	1665	5		
6	8	11	3.3	2.3	1793	5		
7	8	10	3.7	2.6	1530	3	50%	38%

CI, cardiac index; CO, cardiac output; CVP, central venous pressure; LVEF, left ventricular ejection fraction; PCWP, pulmonary capillary wedge pressure; Post-op, post operation; RVFAC, right ventricular fractional area change; SVR, systemic vascular resistance; VIS, vasoactive-inotropic score = dopamine×1 + dobutamine×1 + epinephrine×100 + norepinephrine×100 + vasopressin×10

Due to the lack of preoperative aortic computed tomography (CT) imaging, an appropriate "Datascope Linear 34 French catheter" (height range 152–162 cm, sheath size 7.5Fr, balloon diameter 15 mm, balloon length 221 mm) was selected based on the patient's petite stature. The insertion was uneventful, and post-placement X-ray confirmed correct positioning of the balloon tip at the second intercostal space (Fig. 1A). With the support of IABP, the patient's hemodynamics improved, allowing gradual medication reduction by day 4 (Table 1). Echocardiography following the intervention revealed improved cardiac contractility, with an LVEF of 40%. However, despite the enhanced cardiac output, a marked elevation in serum bilirubin levels was observed, which did not align with the clinical presentation. Specifically, the TB levels increased from 86.2 μmol/L on day 2 to 787.6 μmol/L by day 5, accompanied by a concurrent rise in DB. Concomitantly, alanine aminotransferase (ALT) and aspartate aminotransferase (AST) peaked on day 2, reaching 3292 U/L and 5492 U/L respectively, before gradually declining, with Gamma-Glutamyl Transferase (GGT) exhibited a less pronounced increase.

As initial medical interventions proved inadequate, plasma exchange therapy was initiated on day 5 to mitigate hyperbilirubinemia. However, the TB levels continued to rise, necessitating additional plasma exchange the following day. Investigation into post-cardiac surgery jaundice revealed a DB/TB ratio of approximately 50–60%, along with an absence of progressive anemia, no detectable valvular leaks on ultrasound, and normal hemolysis studies ruling out hemolytic jaundice. Furthermore, there was no evidence of drug-induced liver injury or any abnormalities on viral hepatitis markers and abdominal ultrasound.

Abdominal CT examination performed on day 7 demonstrated normal liver size and morphology, with a homogeneous parenchymal density. The imaging revealed no anatomical abnormalities in the portal venous drainage system and no dilatation of the intra- or extrahepatic bile ducts. However, it did show bile stasis in the gallbladder, a fullness in the pancreatic head, and a blurred retroperitoneal fat space, collectively raising the suspicion of concurrent pancreatitis. Notably, careful review of the imaging indicated that the distal end of the patient's IABP balloon had extended beyond the celiac trunk, reaching the origin of the renal artery (Fig. 1B). Furthermore, the patient's abdominal imaging revealed a slender abdominal aortic diameter of approximately 16 mm. When the IABP balloon was fully inflated, it closely adhered to the aortic wall, nearly occupying the entire segment of the aorta through which it passed (Fig. 1C). Consequently, we hypothesize that the hepatic impairment may be associated with reduced hepatic blood flow due to the celiac trunk obstruction by the IABP balloon. Alongside the evidence of liver damage, the patient also displayed elevated amylase levels and radiological signs indicative of pancreatitis.

Despite the absence of overt abdominal pain or physical examination findings such as abdominal tenderness and rebound tenderness, the patient exhibited symptoms suggestive of impaired digestive function, including abdominal distension, gastric retention, and diminished bowel sounds, which may also be linked to IABP-related hypoperfusion. Considering these findings in conjunction with the patient's improved cardiac function and hemodynamics (Table 1), we promptly removed the IABP on day 7, reaching a TB level of 350.8 μmol/L and a DB level of 196.2 μmol/L by day 8, with a gradual decrease thereafter. By day 11, the patient's condition had improved significantly, leading to her transfer to the general ward. She was discharged one month postoperatively with a TB level of 65.9 μmol/L (Fig. 2).

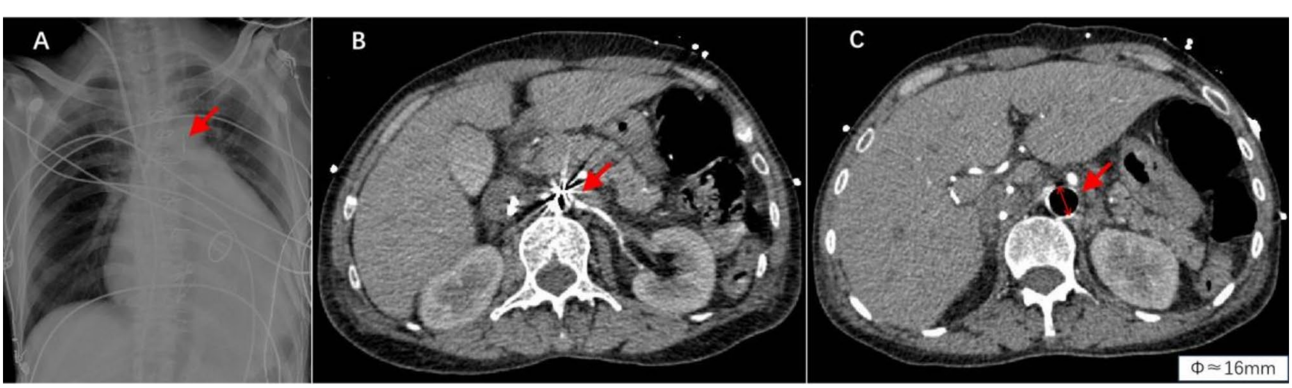

Fig. 1 The position of the IABP balloon in the patient's X-ray and CT scan. (**A**) Chest X-ray confirmed correct positioning of the balloon. (**B**) The distal end of the IABP balloon extended to the renal artery ostium. (**C**) The diameter of the abdominal aorta is about 16 mm, the inflated IABP balloon nearly blocked the narrow abdominal aorta. CT, computed tomography; IABP, intra-aortic balloon pump

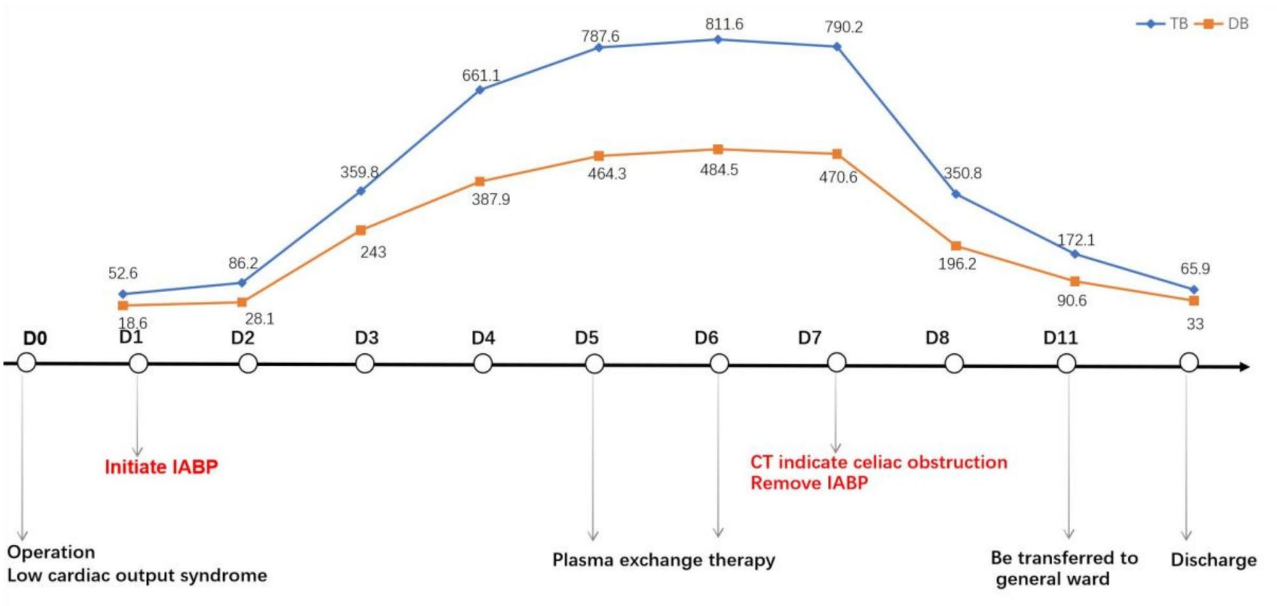

Fig. 2 Timeline
CT, computed tomography; DB, direct bilirubin; IABP, intra-aortic balloon pump; LVEF, left ventricular ejection fraction; TB, total bilirubin

Discussion and conclusions

Low cardiac output syndrome is a common postoperative complication following cardiac surgery, with an incidence rate of approximately 10.1%. Specifically, the incidence rate after isolated mitral valve replacement is reported to be 10.8% [2]. High-risk factors for this complication include elderly females, preoperative low LVEF, combined surgical procedures, preoperative dialysis, advanced New York Heart Association (NYHA) functional class of III or IV, peripheral arterial disease history, and mitral valve surgery for mitral regurgitation [3].

The patient in this case was a postmenopausal elderly female with normal preoperative echocardiographic left ventricular function (LVEF 68%), no coronary artery disease, a relatively short cardiopulmonary bypass and aortic cross-clamp time, and no specific myocardial protection method utilized. Postoperatively, there was progressive reduction in left ventricular contractility, particularly with spherical changes at the apex. After ruling out perioperative myocardial infarction based on electrocardiogram and cardiac biomarkers, we attributed the development of postoperative left ventricular dysfunction to surgical trauma, stress, and inflammatory responses.

Currently, short-term mechanical support options for postoperative left ventricular failure include IABP, Impella, and veno-arterial extracorporeal membrane oxygenation (VA ECMO). IABP is the primary choice for temporary circulatory support in critically ill patients with mild to moderate heart damage following cardiac surgery, is widely used in clinical practice [4]. This technique involves inserting a catheter with a balloon into the descending aorta at the distal end of the left subclavian artery. The balloon inflates during diastole, boosting diastolic pressure, enhancing myocardial oxygen delivery, and improving coronary artery perfusion. In systole, rapid deflation of the balloon reduces left ventricular afterload, enhances cardiac output, and optimizes oxygen delivery [5–6].

Despite its benefits of IABP, balloon implantation can result in various complications, with lower limb ischemia being the most commonly reported. Research on visceral ischemia, however, is limited, likely due to challenges in early detection [1]. Rastan et al. [7] observed vascular damage in at least one visceral artery among 61 out of 63 patients with IABP implantation who underwent chest and abdominal CT scans, with the celiac trunk (96.8%) and superior mesenteric artery (87.3%) being most affected, and approximately 23.8% of these patients requiring laparotomy for mesenteric ischemia. Although advancements in implantation techniques and balloon catheter enhancements have markedly reduced IABP complications in recent years, visceral ischemia remains a formidable and insidious complication, capable of instigating irreversible organ damage and adverse outcomes [8].

Improper balloon positioning and displacement are considered primary factors contributing to visceral ischemia associated with IABP use. Theoretically, the closer the balloon is positioned to the aortic valve, the greater the increase in diastolic pressure. However, anatomical constraints within the aortic arch limit the balloon's position. Consequently, the hemodynamic support provided by IABP largely depends on precisely positioning the balloon's tip 1 to 2 cm below the origin of the left subclavian artery [9]. In this case, immediate post-implantation adjustments and calibration of the balloon tip's position were conducted through bedside chest X-rays. Additionally, daily verification of the external length of the IABP catheter and routine bedside chest X-rays were performed to ensure the balloon's correct placement.

Inappropriate balloon size is another significant factor contributing to visceral ischemia associated with IABP use. The ideal IABP balloon should span from the left subclavian artery to the celiac artery, with an inflation diameter ranging from 90 to 95% of the aortic diameter [1]. Presently, IABP balloon sizes are typically tailored to patient height and vascular anatomy, with balloon volumes ranging from 25 ml to 50 ml and lengths spanning from 178 mm to 258 mm. However, despite this height-based selection, a disparity between aortic and balloon lengths can still ensue, culminating in occlusion of visceral arterial branches and subsequent organ ischemia [10]. Cho et al. [11] noted a 29% renal artery involvement rate in patients of heights ranging from 163 to 183 cm when employing a 40 ml balloon as per guidelines. This discordance is particularly prevalent in petite individuals. Similarly, autopsies in Germany revealed balloon coverage of the celiac trunk and superior mesenteric artery in select patients [12]. Given that height and thoracoabdominal aorta length exhibit a weak correlation influenced by age, gender, and ethnicity, relying solely on patient height for balloon sizing may prove inadequate. A more comprehensive approach is necessary to prevent aortic-balloon mismatches and the associated risks of visceral ischemia.

Gelsomino et al. [13] compared the changes in blood flow within the mesenteric and coronary arteries during IABP supporting using a 40 ml short balloon versus a standard balloon in a porcine model of myocardial ischemia-reperfusion. The authors found that the short balloon, in contrast to its standard counterpart, prevented visceral ischemia while maintaining the effectiveness of the IABP on the heart and coronary vessels. Furthermore, Itoh et al.'s research proposed adjusting the IABP assist ratio from 1:1 to 1:2 and extending balloon deflation intervals as a means to improve ischemic conditions in cases of hepatic and renal ischemic injuries associated with IABP use [14].

In the case presented, the patient was a female with a height of 156 cm and a BMI of 18. 8 kg/m^2, indicative of a petite stature. Adhering to the manufacturer's guidelines recommending suitability for heights between 152 and 162 cm, a "Linear 34 French catheter" was selected for IABP insertion [15]. However, in the days following the implantation, the patient developed severe progressive jaundice and manifestations related to abdominal organ ischemia.

The potential mechanisms underlying post-cardiac surgery hyperbilirubinemia are multifaceted. In addition to the hepatic perfusion obstruction associated with the IABP balloon, factors such as hepatic stress during cardiopulmonary bypass surgery, ischemia-reperfusion injury, systemic inflammatory responses, and the release of inflammatory mediators can collectively impair liver function, impacting bilirubin metabolism and excretion [16]. Moreover, postoperative complications like hypovolemic shock, right heart failure, and infections can also adversely affect liver function, disrupting bilirubin metabolism.

In this case, the advancement of progressive jaundice did not correspond with the gradual amelioration of cardiac function and could not be attributed to pancreatitis. By integrating the patient's chest and abdominal CT findings with the timing of jaundice progression, the authors hypothesized that this discrepancy stemmed from an aortic and balloon mismatch. Consequently, prompt removal of the IABP was initiated, leading to a swift normalization of serum bilirubin levels on the second day, thus substantiating the initial hypothesis.

In conclusion, the selection of IABP balloon sizes should not be based solely on patient height, as demonstrated in this case. Rather, the optimal approach involves measuring the distance from the left subclavian to the celiac trunk, as well as the minimum aortic diameter, using aortic computed tomography angiography (CTA). For patients without access to preoperative aortic CTA, especially those at high risk, consideration should be given to using a smaller balloon size or alternative mechanical support such as VA ECMO to mitigate vascular complications.

Additionally, monitoring for IABP-related visceral ischemia, in addition to common complications like lower limb ischemia, is crucial. For cases presenting with unexplained severe jaundice post-IABP implantation, a proactive approach in seeking imaging evidence to assess its association is necessary. If visceral ischemia related to the IABP balloon is suspected, early IABP removal is imperative. For severe cases not meeting removal criteria, prompt initiation of VA ECMO should be considered. For hemodynamically stable cases not meeting removal criteria, reducing the IABP balloon inflation volume can alleviate arterial flow obstruction and visceral ischemia, preventing further irreversible adverse events.

Abbreviations

IABP	Intra aortic balloon pump
LVEF	Left ventricular ejection fraction
RAFAC	Right ventricular fractional area change
CPB	Cardiopulmonary bypass
ACC	Aortic cross-clamp
PCWP	Pulmonary capillary wedge pressure

CO	Cardiac output
CVP	Central venous pressure
VIS	Vasoactive-inotropic score
TB	Total bilirubin
DB	Direct bilirubin
ALT	Alanine aminotransferase
AST	Aspartate transaminase
CT	Computed tomography
GGT	Gamma-glutamyl transferase
NYHA	New York Heart Association
VA ECMO	Veno-arterial extracorporeal membrane oxygenation
CTA	Computed tomography angiography

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Author contributions
HW: conceptualization, formal analysis, data curation, and writing-original draft. ZC: writing-review and editing. LL: writing review, funding acquisition and editing. MF: conceptualization, project administration, funding acquisition, writing review and editing. All authors contributed to the article and approved the submitted version.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The studies involving human participants were reviewed and approved by Ethics Committee of Guangdong Provincial People's Hospital. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements. Written informed consent was obtained from the participant/patient(s) for the publication of this case report.

Consent for publication
This manuscript is approved by all authors for publication.

Competing interests
The authors declare no competing interests.

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