Is subdural hemorrhage after pulmonary endarterectomy underrecognized?

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Computed tomography scan of the brain showing an acute hyperintense subdural hemorrhage (red arrow) after pulmonary endarterectomy.

Central Message

A high incidence of subdural hemorrhage was noted in our series of patients with chronic thromboembolic pulmonary hypertension post-pulmonary endarterectomy, which may have been underrecognized. The significance and management of this complication is discussed.

See Editorial Commentary page 2043.

Video clip is available online.

Pulmonary endarterectomy (PEA) is part of the treatment options for suitable patients with chronic thromboembolic pulmonary hypertension (CTEPH),¹ affording improved quality of life and survival. Subdural hemorrhage (SDH) is a potential complication of PEA and may result from a combination of factors, including the use of anticoagulation therapy, deep hypothermic circulatory arrest, intracranial fluid shifts, and changes in perfusion. However, the incidence of SDH has previously not been commonly reported. In one series of patients undergoing PEA in chronic thromboembolic disease (CTED), an incidence of 14% was reported.² In the present study, we examined the incidence and management of CTEPH patients with SDH post-PEA (Video 1).

METHODS

This is a retrospective case series of consecutive CTEPH patients who underwent PEA between November 2016 and August 2017 from an Asian tertiary pulmonary hypertension center. Our multidisciplinary team received training at 2 expert PEA centers (San Diego and Papworth, UK), and all the procedures were proctored by a senior surgeon from Papworth. All patients were managed perioperatively in accordance with published Western protocols,³⁻⁶ with anticoagulation stopped before surgery and subcutaneous enoxaparin started at 24 hours post-PEA if no contraindications exist. Initially, patients with neurologic signs and symptoms were scheduled for a noncontrast brain computed tomography (CT) scan. Subsequently, all patients post-PEA were routinely scanned in

view of the higher incidence of SDH noted. This study was approved by the institutional Ethics Review Board (Singhealth CIRB 2017/2388).

RESULTS

A total of 10 patients (8 females; mean age, 56.7 years [range, 45-64 years], mean pulmonary artery pressure 48.5 mm Hg [range, 37-67 mm Hg]) underwent PEA. Mean cardiopulmonary bypass, cross-clamp, and deep hypothermic circulatory arrest times were 305 ± 44 minutes, 84 ± 29 minutes, and 46 ± 15 minutes, respectively.

Seven of the 10 patients underwent brain CT scan postprocedure (2 with headache, 1 with delirium, 1 with an accidental fall, and 3 asymptomatic). The remaining 3 patients were not scanned as they were part of the earlier cohort and were asymptomatic. Six patients had SDH (2 headache, 1 delirium, 1 accidental fall, 2 asymptomatic). One symptomatic patient with headache had a mild midline shift and required a frontal burr hole and suboccipital craniectomy for evacuation of SDH on postoperative day 4.

VIDEO 1. Subdural hemorrhage after pulmonary endarterectomy: importance and relevance. Video available at: [https://www.jtcvs.org/article/S0022-5223\(18\)31763-X/fulltext](https://www.jtcvs.org/article/S0022-5223(18)31763-X/fulltext).

The remaining patients had a small SDH that were managed conservatively with reversal and cessation of anticoagulation. Anticoagulation was resumed at varying times (range, 11 days to 9 weeks postoperatively) after stability on repeat brain CT and on consult with the neurosurgical team. No thrombotic events (eg, stroke, pulmonary embolism, deep vein thrombosis) were noted during the period when anticoagulation was stopped (Table 1).

At follow-up (range, 4 months to 1 year), there was a significant reduction in pulmonary pressures for all patients and no mortalities. No neurologic deficits were noted.

DISCUSSION

In our case series, the overall incidence of SDH was 60% (noting that the first 3 patients in our series were asymptomatic and not routinely scanned). Although SDH is a known complication, the data on its incidence is sparse. A large international registry from Europe and Canada⁵ did not mention the incidence of SDH, as did a large cohort from United States.^{6,7} Studies from Asian countries like Japan and Taiwan,^{8,9} as well as a systematic review,¹⁰ also did not mention any cases of SDH. The Papworth group reported a 14% incidence of SDH (6 out of 42 patients) in its series of CTED patients undergoing PEA, all of whom had a small SDH requiring

no intervention.² They did not routinely screen all patients. Our higher incidence could be a result of routine screening for SDH postoperatively. In addition, CTED patients might not be comparable to CTEPH patients, with a potentially higher disease burden and worse hemodynamics in the latter. Excluding the 2 asymptomatic patients, the patient with an accidental fall, and the patient with delirium (likely due to postoperative stressors), the “revised” incidence of symptomatic SDH in our cohort would be 20%, slightly higher than that reported by the Papworth group.

Several causes of SDH have been postulated.¹¹⁻¹³ SDH after cardiac and aortic surgeries have been reported.^{11,12} In a series of patients undergoing aortic surgery, 15% were found to have symptomatic SDH, all of which were managed conservatively.¹¹ First, rapid fluid shifts may occur in the postoperative period as a result of postoperative diuresis (from the mannitol in the bypass solution and the mannitol and furosemide given postoperatively to maintain “dry lung,” as well as the reduction in right ventricular afterload and improvement in cardiac output). Second, the deep hypothermic protocol with circulatory arrest and subsequent rewarming may cause marked perfusion changes in the brain, with the vasoconstrictive effect of hypothermia and subsequent vasodilating effect of rewarming. The foregoing factors may result in shearing of the bridging veins between the 2 meningeal layers, leading to SDH.¹¹⁻¹³ In addition, Asians are known to be at a higher risk of intracranial hemorrhage compared with their Western counterparts.¹⁴ The routine early resumption of anticoagulation may contribute to this phenomenon.

The clinical significance of this high incidence of SDH is uncertain, and the question remains as to whether if these generally small SDHs would have any major clinical consequences (especially the 2 asymptomatic SDHs picked up on routine screening). Nevertheless, we describe our experience in effectively dealing with this issue. Apart from 1 patient who had a mild midline shift necessitating burr hole drainage and craniectomy, the remaining 5 patients with small SDH were treated effectively with reversal and cessation of anticoagulation. Anticoagulation was resumed on stability/improvement of the bleed on repeat CT brain. Interestingly, and fortuitously, although anticoagulation was stopped for a few weeks in several patients, no thrombotic events were noted.

A major limitation of this study is that preoperative brain CT scans were not performed to document the exact onset of SDH, and patients on chronic oral anticoagulation are known to be more susceptible to SDH.¹⁵ Nevertheless, the hyperintense appearance on CT indicates an acute onset, likely in the perioperative period. Standard protocols recommend early resumption of anticoagulation, usually on postoperative day 1, as well as achievement of

TABLE 1. Characteristics of patients with SDH after PEA

Characteristic	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Age, y	45	67	55	61	52	57
Sex	Female	Female	Female	Female	Female	Male
Preoperative anticoagulant	Warfarin	Warfarin	Warfarin	Warfarin	Rivaroxaban	Warfarin
Cardiopulmonary bypass time, min	303	356	319	230	311	283
Deep hypothermic circulatory arrest time, min	47	58	54	14	42	36
Initiation of enoxaparin	POD 0 (anti-phospholipid syndrome)	POD 1	POD 1	POD 1	POD 1	POD 1
Symptom	Headache	Headache	Delirium	Accidental fall	Asymptomatic	Asymptomatic
SDH*	Acute	Acute-on-chronic	Acute	Acute-on-chronic	Acute	Acute
Location of SDH	Bilateral frontal and posterior fossa	Left frontoparietal and occipitoparietal	Left posterior fossa	Left frontoparietal	Left frontoparietal, posterior falx and right tentorial	Right temporo-occipital
Timing of diagnosis	POD 4	POD 8	POD 8	POD 5	POD 7	POD 6
Intervention	Burr hole and craniectomy	Conservative	Conservative	Conservative	Conservative	Conservative
Resumption of anticoagulation	Warfarin resumed at 5 wk (repeat CT at 8 wk showed complete resolution)	Warfarin resumed at 9 wk (repeat CT at 11 wk showed complete resolution)	Warfarin resumed at 3 wk (repeat CT at 6 wk showed complete resolution)	Warfarin resumed at 3 wk (repeat CT at 6 wk showed complete resolution)	Dabigatran resumed on POD 12 (repeat CT at 8 wk showed complete resolution)	Dabigatran resumed on POD 11 (repeat CT at 10 wk showed complete resolution)
Net fluid balance for first 24 h, mL	−1896	−400	−960	−1000	−1600	−500
Serum osmolality on POD 1, mmol/kg	325	324	320	318	318	325
CVP, preoperative vs POD 0-1, mm Hg†	22 vs 9	16 vs 10	8 vs 9	7 vs 8	14 vs 13	12 vs 10
Mean PA pressure, preoperative vs POD 0-1, mm Hg†	54 vs 24	49 vs 37	67 vs 43	40 vs 35	42 vs 27	46 vs 26
PVR, preoperative vs POD 0-1, Woods†	10.5 vs 3.2	11.8 vs 6.8	14 vs 6.6	14 vs 10.9	8.9 vs 4.6	10.4 vs 3.2

POD, Postoperative day; SDH, subdural hematoma; CT, computed tomography; CVP, central venous pressure; PA, pulmonary artery; PVR, pulmonary vascular resistance.

*Preoperative, electively at a separate admission before the operation; POD 0-1, postoperative day 0 or 1 in the intensive care unit. †A hyperdense SDH on CT was defined as acute, and an isodense or hypodense SDH on CT was defined as chronic.

negative balance to avoid pulmonary edema; however, these protocols have been based mainly on Western cohorts.²⁻⁵ Our team acknowledges that Asians may behave differently, and in light of our experience, are adopting a more cautious approach. All patients will undergo baseline brain CT before surgery and also before restarting anticoagulation postoperatively. We hope to report these findings at a later stage.

CONCLUSIONS

In this small series of patients with CTEPH post-PEA, a higher incidence of SDH was encountered. A fair proportion of the cases were asymptomatic, and this generally did not result in significant morbidity or mortality. Further research is needed to examine the mechanism of this pertinent complication, identify preventive measures, and elucidate its clinical significance.

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