The rate of cerebrovascular accident with mitral valve endocarditis is reported to be at 35.5%. Between 10% and 40% of left-sided infective endocarditis is accompanied with neurological dysfunction. Literature concludes that rapid intervention with early valve surgery, even within 72 hours of the intracranial hemorrhage (ICH), is neither associated with increased mortality nor associated with higher neurological morbidity, regardless of the size of the hemorrhagic stroke preoperatively. To our knowledge, this is the first report of using minimal cardiopulmonary bypass (MCPB) for valve surgery in infective endocarditis patients with ICH. MCPB allows lower priming volume compared to conventional cardiopulmonary bypass (CCPB) and allows a decrease in heparin dose: 150–200 IU/kg for MCPB vs 300 IU/kg for CCPB. Written consent was obtained from the patient before publication.

**CASE DESCRIPTION**

A 19-year-old man, 48 kg, 172 cm, with a background of mitral valve endocarditis and prolapse, intracerebral and intracerebellar hematoma, and a mycotic cerebral aneurysm underwent emergency mitral valve replacement during minimal cardiopulmonary bypass (total priming volume, 800 mL; autologous retropriming, activated clotting time <300 seconds) 1 day after undergoing endovascular coil embolization of the aneurysm. Postoperatively, there were no extensions of the intracerebral and intracerebellar hematoma. After intensive rehabilitation therapy, the patient recovered fully except for residual bilateral claudication because of preoperative bilateral embolism to both superficial femoral arteries. (A&A Practice. 2018;10:144–7.)

The patient had an in situ right radial arterial line and a left internal jugular central venous line. The patient was bated and sedated, and norepinephrine and dobutamine were started. After a wake-up test, the patient was obeying commands and did not reveal any neurological deficits. The patient was lethargic with a Glasgow Coma Scale of 15/15, leg edema, asthenia, and persistent fever. In hospital, the patient was treated with 2 mg fondaparinux subcutaneously twice daily for 7 days and then 5 mg apixaban orally twice daily. The patient had an in situ right radial arterial line and a left internal jugular central venous line. The patient was bated and sedated, and norepinephrine and dobutamine were started. After a wake-up test, the patient was obeying commands and did not reveal any neurological deficits.

To keep total priming volume (800 mL) and heparin use as low as possible, a retrograde priming technique with the patient’s own blood via venous and arterial cannulae was utilized. During MCPB, Hb dropped to 7.8 (hematocrit, 23%),
and 2 units of red blood cells were given to obtain an Hb of 8.5–8.8 g/dL (hematocrit, 25%–26%). Mean arterial blood pressure (MAP) was maintained above 70 mm Hg (range, 60–93 mm Hg) with norepinephrine (peak infusion rate, 1 mg/h). Anterograde and retrograde cold (20°C) cardioplegia was administered every 15 minutes. Central body temperature, measured in the bladder, was cooled down to 33°C, and at the end of cardiopulmonary bypass (CPB), temperature increased to 36.8°C. Transesophageal echocardiography confirmed the presence of large vegetations and damage of the mitral annulus (Figure 4). Surgical time was kept to a minimum by proceeding directly to replacing the entire valve by a biological mitral valve. Nonin cerebral oximeter (Nonin Medical Inc, Plymouth, MN) for cerebral perfusion monitoring displayed values for tissue oxygen saturation of both hemispheres above 60 with its lowest value at 53 in the right hemisphere at the end of surgery.

Activated clotting time (ACT) before heparin administration was 133 seconds. In total, 10,000 units of heparin were given. After a peak of 401 seconds, on controls, every 30 min, ACT remained at 283 and 289 seconds. After MCBP, based on a homeostasis management system, 100 mg protamine was given and ACT normalized at 126 seconds. MCBP time was 74 minutes, aortic clamping time 56 minutes and MCBP weaning lasted for 18 minutes. Atrioventricular pacemaker stimulation was temporarily used at a rate of 90/min.

Four units of fresh frozen plasma and 1 unit of platelets were transfused. Postoperatively, the patient was transferred to the intensive care unit with norepinephrine at 0.032 mg/h. The 18-day intensive care unit stay were characterized by a reoperation to remove thromboemboli from the left popliteal artery, ventilation-acquired pneumonia followed by tracheostomy,
and percutaneous gastric feeding. After 4 weeks in rehabilitation medicine, he had good neurological recovery, no loss in memory capacity, no signs of neurological deficits, and was discharged home. Due to bilateral emboli into the legs, the patient kept residual bilateral claudication. On follow-up, a control nuclear magnetic resonance showed resorption of the occipital and left cerebellar hematoma.

DISCUSSION
Low postoperative incidence of hemorrhagic stroke, even in case of decompressive craniotomy, is a strong argument to surgically remove the embolic source rapidly and thereby minimizing the risk of secondary hemorrhage. Given the serious state of our patient, rapid surgical intervention under CPB with heparin was justified even 1 day after hospital admission.

Before cardiac surgery, the patient underwent coil embolization of the mycotic aneurysm. Lin et al reported that early clipping or endovascular treatment with antibiotic therapy of a ruptured mycotic cerebral aneurysm can reduce mortality by up to 11%, decreasing the risk of ICH during CPB.

In a case of a 12-year-old boy with ICH secondary to infective endocarditis and aortic regurgitation undergoing aortic root replacement 5 days after his hemorrhagic stroke, a priming volume of 1000 mL was used. In our case, priming was 800 mL for a young adult. Growing evidence points toward favorable neurological outcome and attenuation of postoperative neurocognitive impairment with MCPB after coronary artery bypass grafting. In contrast to CCPB, the use of MCPB reduces hemolysis, hemodilution, and blood loss for coronary arterial bypass surgery. However, consequences of air entering venous lines, thereby stopping the pump or inducing embolization requires the absence of atrial septal defect for MCPB use. To reduce dilution of coagulation factors, we also applied retrograde priming via the venous cannula of the MCPB circuit by using the patient’s own blood, which is proven to be a safe method. As anemia constitutes a risk factor for stroke, we aimed our Hb level >8.5 g/dL and even a Hb level >9.2 g/dL has been recommended.

An ACT of 250 seconds during MCPB was described in the literature to reduce blood transfusions, and based on experience, we considered an ACT level of 300 seconds sufficient for MCPB with a priming volume as low as 800 mL. We used phosphorylcholine-coated CPB tubings to reduce systemic dose of heparin during CPB, but other CPB tubings also exist such as tubings coated with heparin and nafamostat mesilate.

Currently, literature does not provide any recommendations on MAP in patients with ICH during CPB. In case of vasospasm, a higher MAP should be targeted. Comparing pump MAP of 80–100 mm Hg and 50–60 mm Hg, literature describes a significantly higher incidence of neurologic morbidity in the low MAP group, and more infarcts are reported with 10 mm Hg decrease in MAP from preoperative baseline during CPB. In absence of further evidence, we suggest that the average preoperative MAP of the awake patient could serve as a reference point for a MAP used during CPB.

In a case report using hypothermic CPB of 21°C for infective endocarditis valve surgery with ICH, MAP was maintained at 75–90 mm Hg. However, although hypothermic CPB could contribute to coagulopathy increasing ICH, it would also reduce or eliminate the use of systemic heparin for CPB. Considering European resuscitation guidelines 2015, deep hypothermia during surgery should be avoided in patients with ICH.

CONCLUSIONS
Threat of reembolization justifies rapid surgical intervention under CPB with heparin even within 72 hours of the event of ICH. Preoperative embolization of ruptured mycotic cerebral aneurysm reduces mortality and the risk of ICH during CPB. MCPB with retrograde blood priming allows decrease of heparin dose, reduces blood loss, and favors neurological outcome and neurocognitive function in patients with ICH. Hb levels >92 g/dL should be aimed for with a MAP > 75 mm Hg with preferably normothermic CPB to reduce the occurrence of intraoperative stroke.

ACKNOWLEDGMENTS
We thank Dr Michel Campech and Dr Alexandre Dine of the Department of Rehabilitation Medicine of the University Hospital Felix Guyon of Saint Denis, Reunion Island, France (UHFG) for providing detailed data of the neurological and physiological follow-up of the patient.

We also express our gratitude to Dr Magarita Beltran, neuroradiologist (UHFG), for discussing the medical images of the patient and Mr Guillaume Romagne, supervising nurse of the Department of Radiology (UHFG) who also contributed for the preparation of radiological images for the publication. Also thanks to Dr Benjamin Delmas (UHFG) for details on anesthetic management and to the general intensive care unit (UHFG) for providing us all information on intensive care unit management.

DISCLOSURES
Name: Gabor Kiss, MD.
Contribution: This author helped search the literature, and prepare and edit the manuscript.
Name: Eric Braunberger, MD.
Contribution: This author helped edit the manuscript.
This manuscript was handled by: Raymond C. Roy, MD.

REFERENCES
1. Rossi M, Gallo A, De Silva RJ, Sayeed R. What is the optimal timing for surgery in infective endocarditis with cerebrovascular complications? Interact Cardiovasc Thorac Surg. 2012;14:72–80.
2. Wan S, Sung K, Park PW, et al. Stroke is not a treatment dilemma for early valve surgery in active infective endocarditis. *J Heart Valve Dis.* 2014;23:609–616.

3. Vohra HA, Whistance R, Modi A, Ohri SK. The inflammatory response to miniaturised extracorporeal circulation: a review of the literature. *Mediators Inflamm.* 2009;2009:707042.

4. Rupprecht TA, Weil S, Winkler PA, Kreuzer E, Pfister HW. Successful cardiac surgery 24 hours after craniotomy in a patient with infective endocarditis and embolic cerebellar infarction: case report. *J Heart Valve Dis.* 2004;13:228–230.

5. Lin CT, Tranmer B, Durham S, et al. Ruptured mycotic aneurysm and cerebral vasospasm in the setting of endocarditis and heart failure requiring cardiothoracic surgery: case report and review. *World Neurosurg.* 2017;100:711.e13–711.e18.

6. Bays S, Nicholson E, Humphreys N, Parry A. Aortic root replacement after recent intracerebral hemorrhage. *Eur J Cardiothorac Surg.* 2004;26:863–865.

7. Anastasiadis K, Argiriadou H, Kosmidis MH, et al. Neurocognitive outcome after coronary artery bypass surgery using minimal versus conventional extracorporeal circulation: a randomised controlled pilot study. *Heart.* 2011;97:1082–1088.

8. Lisy M, Schmid E, Kozok J, Rosenberger P, Stock UA, Kalender G. Allogeneic blood product usage in coronary artery bypass grafting (CABG) with minimalized extracorporeal circulation system (MECC) versus standard on-pump coronary artery bypass grafting. *Open Cardiovasc Med J.* 2016;10:148–157.

9. Baikoussis NG, Papakonstantinou NA, Apostolakis E. The ‘benefits’ of the mini-extracorporeal circulation in the minimal invasive cardiac surgery era. *J Cardiothorac Vasc Anesth.* 2014;6:391–396.

10. Trapp C, Schiller W, Mellert F, et al. Retrograde autologous priming as a safe and easy method to reduce hemodilution and transfusion requirements during cardiac surgery. *Thorac Cardiovasc Surg.* 2015;63:628–634.

11. Yoshioka D, Toda K, Okazaki S et al; OSCAR Study Group. Anemia is a risk factor of new intraoperative hemorrhagic stroke during valve surgery for endocarditis. *Ann Thorac Surg.* 2015;100:16–23.

12. Nilsson J, Scicluna S, Malmkvist G, et al. A randomized study of coronary artery bypass surgery performed with the Resting Heart™ System utilizing a low vs a standard dosage of heparin. *Interact Cardiovasc Thorac Surg.* 2012;15:834–839.

13. Sakamoto T, Kano H, Miyahara S, et al. Efficacy of nafamostat mesylate as anticoagulation during cardiopulmonary bypass for early surgery in patients with active infective endocarditis complicated by stroke. *J Heart Valve Dis.* 2014;23:744–751.

14. Gottesman RF, Sherman PM, Grega MA, et al. Watershed strokes after cardiac surgery: diagnosis, etiology, and outcome. *Stroke.* 2006;37:2306–2311.

15. von Segesser LK, Garcia E, Turina M. Perfusion without systemic heparinization for rewarming in accidental hypothermia. *Ann Thorac Surg.* 1991;52:560–561.

16. Nolan JP, Soar J, Cariou A, et al; European Resuscitation Council; European Society of Intensive Care Medicine. European Resuscitation Council and European Society of Intensive Care Medicine 2015 guidelines for post-resuscitation care. *Intensive Care Med.* 2015;41:2039–2056.