

A case report on middle cerebral artery aneurysm treated by rapid ventricular pacing

A CARE compliant case report

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Abstract

Rationale: Cerebral aneurysm is a common cause of intracranial hemorrhage, stroke, and death. It is treated with vascular surgeries, such as coil embolism and artery clipping. However, surgery itself is a risk factor that may cause rupture of aneurysm, and leads to irreversible brain damage, and even death. Rapid ventricular pacing (RVP) is a procedure that temporarily lowers blood pressure by increasing heart rate and reducing ventricular filling time. RVP has been widely used to reduce blood vessel tension in many cardiovascular surgeries.

Patient concerns: A 46-year-old man came to our hospital with intermittent right-side headache for 5 years, and left lower limb numbness for 3 months.

Diagnoses: Magnetic resonance imaging (MRI) of the head and digital subtraction angiography confirmed the diagnosis of right middle cerebral artery (MCA) aneurysm.

Interventions: Considering the large size of this MCA aneurysm, RVP was used to reduce blood pressure during MCA aneurysm repair, and to lower the risk of intracranial hemorrhage during procedure.

Outcomes: Post procedure, there was no abnormality detected. Seven weeks after surgery, the patient's muscle tone of right side extremities were grade V and left side extremities were grade IV. Computed tomography angiography confirmed no MCA aneurysm.

Lessons: In cases of aneurysm rupture, RVP will induce a transient "very low pressure" condition, and give a valuable time frame to clip the ruptured aneurysm. Therefore RVP is a safe and effective method to provide transient reduction of cardiac output in intracranial aneurysm patients.

Abbreviations: ASA = American Society of Anesthesiologists, CCTA = coronary CT angiography, DSA = digital subtraction angiography, GCS = Glasgow Coma Score, ICG = indocyanine green, MCA = middle cerebral artery, MRI = magnetic resonance imaging, NYHA = New York Heart Association, PACU = post-anesthesia care unit, RVP = rapid ventricular pacing.

Keywords: case report, cerebral aneurysm, intraoperative aneurysm rupture, rapid ventricular pacing

Editor: N/A.

Ethics approval and consent to participate: Ethical approval was given by the Ethics Committee of Huashan Hospital Fudan University, Shanghai, China. Informed written consent was obtained from the patient for publication of this case report and accompanying images.

Consent for publication: Not applicable.

Availability of data and material: The datasets used and/or analyzed during the current study are all in the manuscript.

The authors have no funding and conflicts of interest to disclose.

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Medicine (2018) 97:48(e13320)

Received: 28 June 2018 / Accepted: 24 October 2018

<http://dx.doi.org/10.1097/MD.0000000000013320>

1. Introduction

Cerebral aneurysm is a common cause of intracranial hemorrhage, stroke, and death.^[1] Rupture of aneurysm is a devastating event with a high mortality. Treatment of cerebral aneurysm is mainly by two procedures under current clinical practice.^[2] The first procedure is coil embolism, in which platinum coil is inserted into the lumen of the aneurysm, and a local thrombus then forms around the coil, obliterating the aneurysmal sac.^[3] The second one is surgical clipping which involves craniotomy and placement of a clip on the blood vessel to exclude the weakened area. Both procedures are associated with different complications. For example, coil embolism may lead to development of thromboembolism,^[4] and intraoperative aneurysmal rupture.^[5] The complications of surgical clipping include new or worse neurologic deficits caused by brain retraction, temporary arterial occlusion, and intraoperative hemorrhage.^[6–8] However, more and more clinical data support that surgical clipping has better safety and efficacy than coil embolism for treating unruptured MCA aneurysms.^[9]

Rapid ventricular pacing (RVP) has been used in many cardiovascular surgeries as a reliable technique to control heart rate (HR) and blood pressure (BP). RVP enforces that ventricular tachycardia and ventricular filling are compromised because of

the high HR and absent atrioventricular synchrony. Thus, reduced stroke volume and cardiac output lead to decreased BP. Recently, there were several reports of using RVP in the surgery to treat cranial aneurysms.^[10–13] There are no major safety issues in those reports. However, because this procedure requires extensive preoperative cardiologic workup of the patient and an experienced neurosurgery and neuroanesthesiology team with much cerebrovascular expertise, actually it remains reserved for selected elective cases and highly specialized centers.

Here we presented a case report of a patient with large MCA aneurysm. The risk of aneurysm rupture in this patient is relatively high due to the size of lesion. Since RVP has been used to reduce BP during aneurysm repairs successfully,^[10–13] the preoperative cardiologic evaluation of this patient supported us to choose RVP procedure to reduce the risk of intraoperative aneurysm rupture.

2. Patient information and clinical findings

The patient was a 46-year-old man. He had intermittent right-side headache for 5 years, and he complained left lower limb numbness for 3 months. Physical examination found no sensory loss in both upper and lower extremities. The patient had normal muscle tone and deep tendon reflex. Magnetic resonance imaging (MRI) of the head, performed without the administration of intravenous contrast material, revealed an aneurysm at right MCA M1 segment, ($5 \times 4 \times 4 \text{ cm}^3$) (Fig. 1). Digital subtraction angiography (DSA) confirmed the diagnosis of right MCA aneurysm (Fig. 2).

The patient had no history of hypertension, diabetic mellitus, and coronary artery disease. New York Heart Association (NYHA) classification was grade I, and American Society of

Anesthesiologists (ASA) classification was grade I. The patient had normal ECG, pulmonary function, echocardiography, Holter, and coronary CT angiography (CCTA) tests.

Considering the size of this MCA aneurysm was large, and patient had good cardiac and pulmonary functions, it was therefore decided to use RVP to reduce BP during MCA aneurysm repair, and to lower the risk of intracranial hemorrhage during procedure.

3. Therapeutic intervention

3.1. Anesthesia procedure, probe placement, and RVP testing

General anesthesia was performed by a team consisting of an anesthesiologist and nurses with experience in cardiac intervention and surgery. The patient was given 1 mg midazolam, 0.5 g fentanyl, 1.0 $\mu\text{g/mL}$ propofol (target-controlled infusion), and levetiracetam to induce anesthesia. The respiratory rate and cardiac function were closely monitored. Local anesthesia was performed by injecting 2% lidocaine around left radial artery. A 4-French introducer sheath was placed in radial artery to set up A-line. On examination, the BP was 106/56 mm Hg, HR was 56 bpm, and oxygen saturation was 99%. A 6Fr catheter was put into left axillary vein under ultrasound guidance to set up C-line. A 5Fr flow directed pacing catheter was inserted into right ventricle, and the probe was inserted around 45 cm and reached the right ventricular apex. Correct positioning of the pacing electrode was confirmed via continuous ECG monitoring under pacer stimulation with a low pacing threshold. External defibrillation pads were placed on the chest wall.

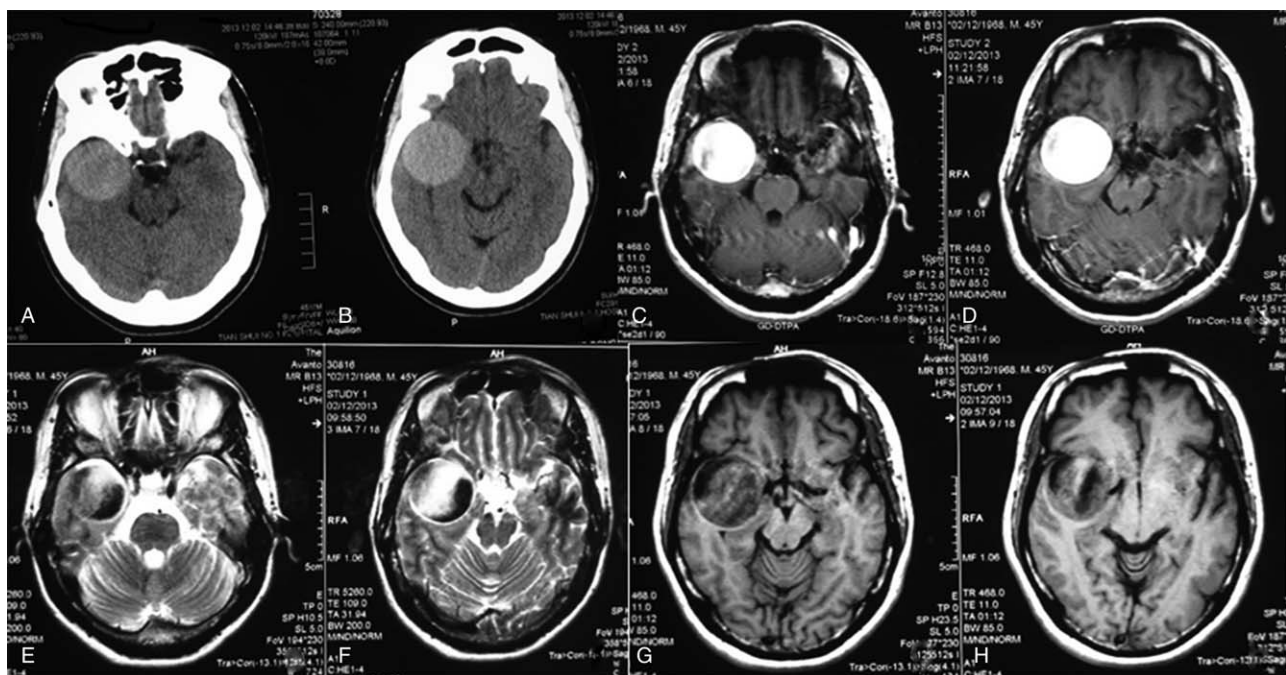


Figure 1. Head CT scan and MRI of patient before surgery. (A–B) Head CT scan. Right temporal area has a high-dense round lesion. The edge of lesion is sharp and no sign of edema. (C–D) Head MRI contrast-enhanced T1-weighted scan. The lesion has strong signal in contrast-enhanced T1-weighted MRI, suggesting it may be an aneurysm. (E–F) Head MRI T2-weighted. (G–H) Head MRI T1-weighted. MRI = magnetic resonance imaging.

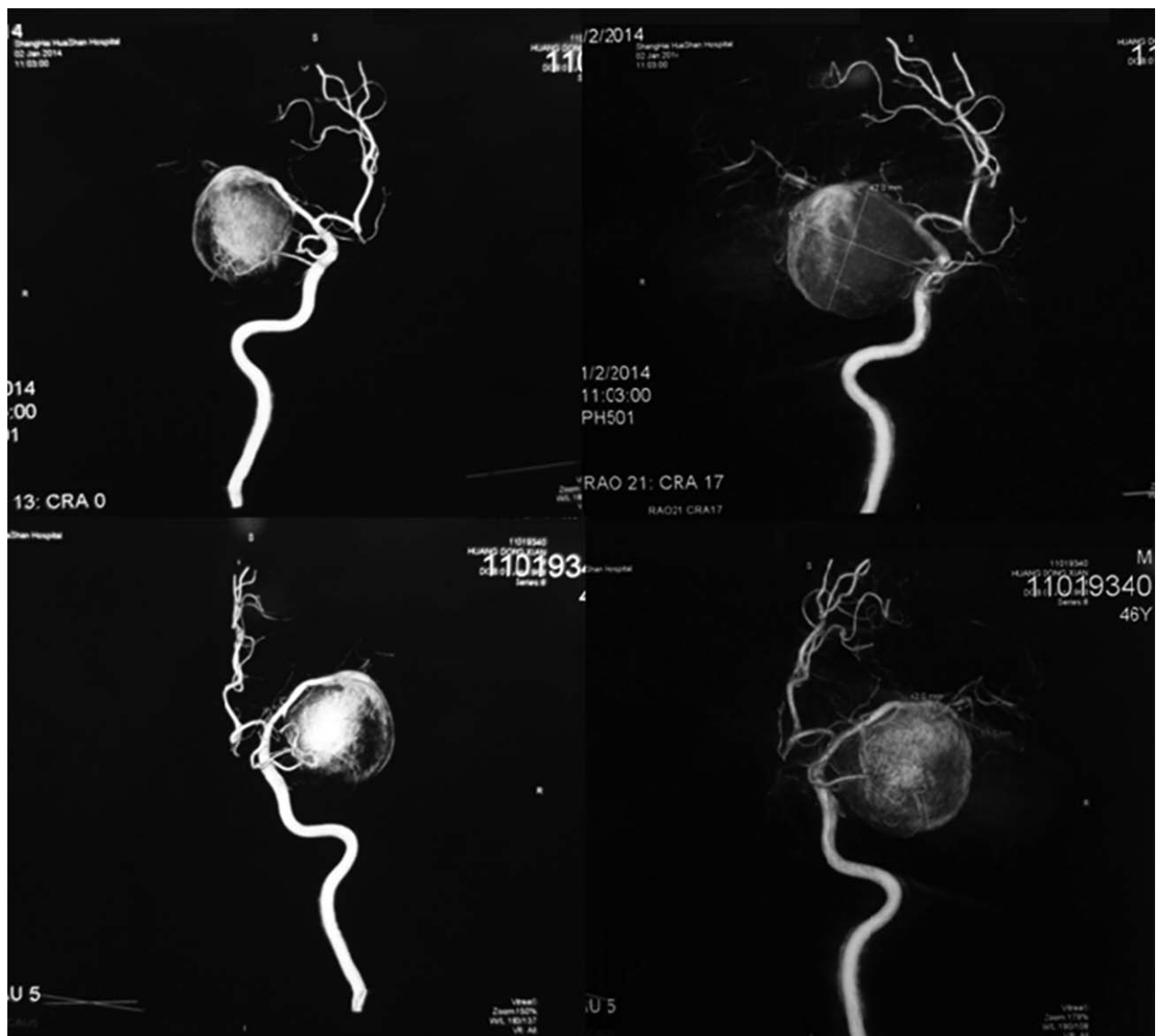


Figure 2. Digital subtraction angiography (DSA) confirmed the MCA aneurysm. MCA = middle cerebral artery.

3.2. Surgical procedure

The patient was put in supine position, and his head was turned toward left side around 20°. Cut skin and temporalis, and exposed frontal bone and temporal bone, and opened a window in this area. Incised the dura, and started to dissect the aneurysm. When the aneurysm was fully exposed, the RVP was started to reduce BP. RVP was induced totally four times during the entire procedure. Twice was induced when isolating aneurysm and twice was started during clip placement. The first RVP lasted 120 s and maximum HR was 130 bpm, and lowest BP reached 58/38 mm Hg. The second RVP lasted 50 s, and maximum HR was 150 bpm, and lowest BP reached 39/21 mm Hg. The third RVP lasted 50 s, and the maximum HR was 160 bpm, and lowest BP reached 29/26 mm Hg. The last RVP lasts 50 s and the maximum HR was 165 bpm, and the lowest BP reached 28/23 mmHg (Fig. 3). There were at least 3 min gap period between each RVP episodes. Every time RVP was induced, the HR reached the maximum HR in 5 s, and the average BP dropped to the lowest level. After that the BP increased gradually in 50 s, and eventually it reached to 58%–80% of BP before RVP induction.

RVP significantly reduced the tension of aneurysm when isolating the MCA M1 fragment, and decreased the risk of rupture. Once the aneurysm was fully exposed, we induced another two episodes of RVP to clip the aneurysm. Intraoperatively, indocyanine green (ICG) video angiography was used to verify aneurysm occlusion as well as parent vessel perfusion after each clip placement.

The patient was in very stable condition during the entire procedure. No vasoactive and anti-arrhythmia drugs were used, and no adjustment of doses of fentanyl and propofol as well. The MCA aneurysm was clipped successfully. The temporary pacing was removed after the surgery. The surgery lasted 6 h and 40 min, and total RVP time was less than 5 min.

3.3. Follow-up and outcomes

The patient was transferred to post-anesthesia care unit (PACU) for observing around 2.5 h. After the patient woke up and the Glasgow Coma Score (GCS) was more than 6, the patient was transferred to ICU. CT scan confirmed no intracranial bleeding,

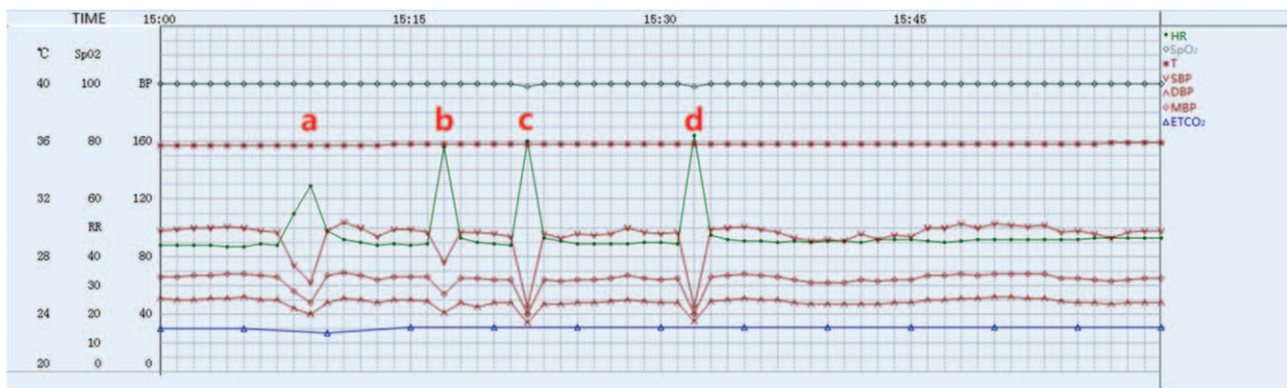


Figure 3. Record of vital sign monitoring during procedure. a, b, c, and d indicated four RVP during surgery. RVP = rapid ventricular pacing.

and there were no arterial blood gas changes during or after RVP, compared with before RVP. The biomarkers for cardiac muscle damages, including CK-MB, troponin T, and ProBNP, were increased at 24h after surgery (Table 1). Seven weeks after surgery, the patient was fully conscious and cooperative. Muscle tone of right side extremities were grade V and left side extremities were grade IV. CTA confirmed no MCA aneurysm (Fig. 4), and the patient was discharged.

4. Discussion

Intracranial aneurysm is a life-threatening condition that usually starts with little symptoms for years. And many patients only have sudden-onset symptoms when the aneurysm is ruptured. The mortality rate of ruptured intracranial aneurysm is very high.^[14] The intracranial aneurysm is mainly managed surgically by coil embolism or clipping. However, surgery itself is a risk factor for aneurysm rupture,^[15] and the rupture can occur in any stage of surgery. The size of aneurysm, the thickness of blood vessel wall, and BP are important factors to predict the risk of intraoperative rupture of aneurysm.^[16-19] For intracranial aneurysm repair surgery, the key is to prevent aneurysm rupture, because rupture will cause blood loss and may lead to irreversible brain damage and other visceral organs and intraoperative bleeding will make it very difficult to have a clean surgical area to clip the aneurysm, and it may cause secondary damage during procedure. Therefore, to reduce the risk of aneurysm rupture is essential to increase survival rate of aneurysm repair surgery.

The size of aneurysm, the thickness of blood vessel wall, and BP are factors that correlated with the risk of aneurysm rupture. Big aneurysm, thinner blood vessel wall, and high BP are associated with higher risk of aneurysm rupture. However, among the three

factors, BP is the only factor that can be managed in current clinical practice.

Adenosine-induced temporary cardiac arrest was widely used to lower BP in many cardiovascular surgeries. It was also used to control BP in the intracranial aneurysm surgery.^[20] A study found that patients whom induced temporary cardiac arrest during intracranial aneurysm repair needed less time to clipping, and slightly less intraoperative aneurysm rupture.^[20] This result supported that inducing temporary cardiac arrest was benefit to patients with aneurysm repair. However, adenosine may have safety issues, as some patients may response to adenosine differently, and patients who are sensitive to adenosine may be overdosed. Second, the duration of cardiac arrest and amplitude

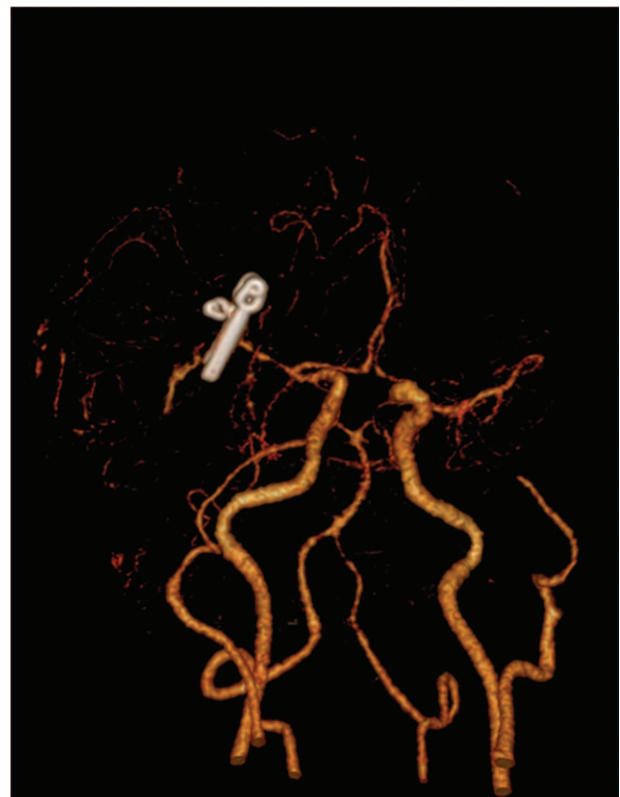


Figure 4. Computed tomography angiography confirmed the MCA aneurysm is clipped. MCA = middle cerebral artery.

Table 1

Level of cardiac biomarkers before and after RVP.

Biomarkers	Before RVP	After RVP			Reference
		2h	4h	24h	
ProBNP	<100	53.9	55.4	188.4↑	<100 (pg/mL)
Myoglobin	<21	200.7↑	943.7↑	125↑	28-72 (ng/mL)
CK-MB	0.46	1.17	7.28↑	9.35↑	<4.87 (ng/mL)
Troponin T	<0.01	<0.01	<0.01	<0.01	0.013-0.025 (ng/mL)

CK-MB=creatine kinase isoenzyme MB, ProBNP=pro b-type natriuretic peptide.

of blood pressure decrease was difficult to control when induced by adenosine.^[21]

RVP became a safer alternative to adenosine to control BP in many cardiac surgeries.^[22–24] RVP enforced ventricular tachycardia and the ventricular filling was compromised because of the high HR and absent atrioventricular synchrony. Thus, reduced stroke volume and cardiac output lead to decreased BP. RVP had better control over the duration and amplitude of blood pressure than adenosine. In addition to general cardiovascular surgeries, recently RVP has been used to control BP during intracranial aneurysm repair surgery.

The benefits of RVP include: reducing the amount of bleeding and providing a clean surgical area; reducing the tension of aneurysm, which will decrease the chance of rupture during surgical isolation and clipping; and in cases of aneurysm rupture, RVP will induce a transient “very-low pressure” condition, and give a valuable time frame to clip the ruptured aneurysm. Therefore, RVP is a safe and effective method to provide transient reduction of cardiac output.

The complications of RVP usually are related with pacing probes, such as penetration of heart, cardiac tamponade, pneumothorax, and ventricular tachycardia. Therefore, it is suggested to thoroughly evaluate patients’ cardiac function, for example, Holter to exclude the sinus malfunctions, coronary computed tomography angiography to exclude coronary artery disease, and echocardiogram to exclude valve-related disease. Defibrillator and anti-arrhythmia drugs should be prepared before performing RVP.

In summary, here we presented a patient with large MCA aneurysm, and he was treated with aneurysm clipping with the assistance of RVP successfully, and discharged with no complications. RVP procedure may benefit intracranial aneurysm patients.

Author contributions

All authors contributed to the study design, collected the data, performed the data analysis, and prepared the manuscript.

Conceptualization: Huahua Gu.

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Investigation: Yi Ping.

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Writing – review & editing: Huahua Gu.

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