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CASE REPORT

# Emergent Coronary Thrombectomy for Acute Myocardial Infarction Immediately Following Craniotomy with Tumor Resection

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## ABSTRACT

The management of perioperative acute myocardial infarction (AMI) following oncologic neurosurgery requires balancing competing risks of myocardial ischemia and postoperative bleeding. There are limited human data to establish the safest timing of antiplatelet or anticoagulation therapy following neurosurgical procedures. For patients with malignancy experiencing AMI in the acute postoperative period, staged percutaneous coronary intervention (PCI) with upfront coronary aspiration thrombectomy followed by delayed completion PCI may offer an opportunity for myocardial salvage while minimizing postoperative bleeding risks. CYP2C19 genotyping and platelet aggregation studies can help confirm adequate platelet inhibition once antiplatelet therapy is resumed.

**Keywords:** Perioperative ACS; Aspiration thrombectomy; Staged PCI; CYP2C19 genotyping; Platelet aggregation

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**Key Summary Points**

Perioperative myocardial infarction is a challenging complication following oncologic neurosurgical procedures.

There are limited human data to guide timing of therapeutic anticoagulation or antiplatelet medication for patients experiencing an acute thrombotic event early after brain tumor resection.

Staged percutaneous coronary intervention with temporizing aspiration thrombectomy may provide myocardial salvage while minimizing risks of postoperative bleeding.

CYP2C19 genotyping and platelet aggregation testing may enable targeted antiplatelet therapy selection in patients with competing bleeding and thrombosis risk factors.

## INTRODUCTION

Perioperative myocardial infarction is an important complication associated with an increased mortality risk following noncardiac surgery [1]. The risk of perioperative cardiac events is more significant for patients undergoing neurosurgical procedures who have chronic antiplatelet and antithrombotic therapy interrupted perioperatively [2]. Utilizing postoperative high-sensitivity troponin levels, a prospective cohort study identified perioperative myocardial injury in 20.5% of patients undergoing elective neurosurgery [3]. Patients undergoing oncologic surgery may face even greater perioperative risks, with one population-based study identifying a more than twofold increase in the incidence of arterial thromboembolism and myocardial infarction in the first 6 months following a new diagnosis of cancer [4].

We present the management of a patient who suffered an ST-segment elevation myocardial infarction immediately following craniotomy with tumor resection and who was managed with a staged coronary interventional procedure to achieve myocardial salvage while minimizing intraparenchymal brain hemorrhage. Written informed consent was obtained from the patient prior to manuscript preparation.

## CASE PRESENTATION

The patient is a 70-year-old man, non-smoker, with a history of stage IIIA non-small cell lung cancer diagnosed 10 years ago treated with neoadjuvant cisplatin and etoposide, lobectomy with radical mediastinal lymphadenectomy, and adjuvant carboplatin and pemetrexed followed by a 5-year course of adjuvant erlotinib. He had a prior anterior myocardial infarction (MI) complicated by cardiac arrest treated with percutaneous coronary intervention (PCI) with drug-eluting stents (DES) to the proximal and mid-left anterior descending (LAD) artery 3 years ago at an outside institution. He completed a course of dual-antiplatelet therapy with aspirin and ticagrelor and had since been on aspirin monotherapy. After several months of increasing forgetfulness, he presented to the hospital and cross-sectional imaging revealed a 5 cm by 7 cm frontal lobe mass with surrounding edema concerning recurrent metastatic disease from lung cancer (Fig. 1). A pre-operative medical evaluation revealed no symptoms at a moderate level of functional capacity and a normal transthoracic echocardiogram. Aspirin was held for 5 days before the planned craniotomy, and he received no other antiplatelet or anticoagulation medications in the preoperative period. A stereotactic left frontal craniotomy with gross total resection of the tumor lasted 5 h and concluded with adequate hemostasis and without intraoperative complication. Postoperative imaging revealed expected postsurgical changes without postoperative bleeding (Fig. 1).

Two hours postoperatively, the patient developed substernal chest discomfort. Serial

electrocardiograms (ECGs) were obtained and demonstrated an evolving anterior wall ST-segment elevation myocardial infarction (Fig. 2). A bedside ultrasound revealed new anterior and septal hypokinesis with moderately reduced left ventricular function. He began to develop an increasing burden of non-sustained ventricular tachycardia prompting the addition of intravenously administered lidocaine.

## Treatment Plan/Decision-Making

A prompt multidisciplinary conversation was held between the critical care, neurosurgical, and cardiovascular medicine teams. It was concluded that the risk of mortality from an acute anterior wall myocardial infarction with increasing ventricular ectopy outweighed the risks of postoperative bleeding associated with single antiplatelet therapy and the use of heparin during coronary angiography. It was considered that intravenous unfractionated heparin and aspirin therapy offered the lowest risk of operative site bleeding, with a preference to avoid $P2Y_{12}$ inhibitor therapy for at least 10 days following the craniotomy.

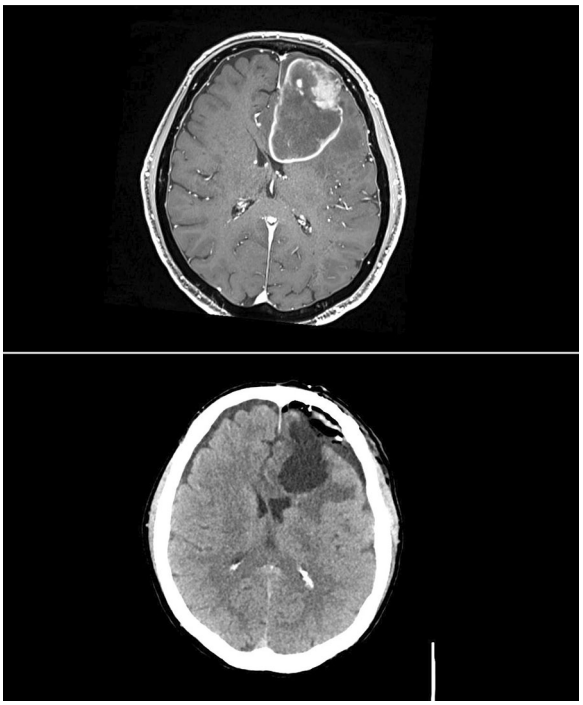


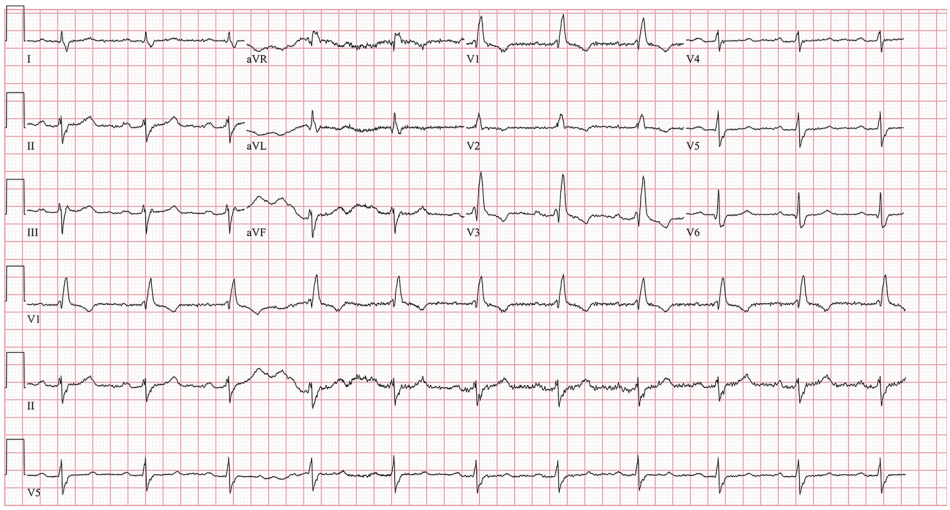
**Fig. 1 Frontal lobe mass pre and post resection.** (Upper panel) Preoperative magnetic resonance imaging (MRI) revealed a large left frontal lobe lesion measuring 5 cm by 7 cm with significant surrounding edema and left-to-right midline shift. (Lower panel) Immediate postoperative computed tomography (CT) revealed expected postsurgical changes without postoperative bleeding

A 600-mg aspirin suppository was immediately administered and coronary angiography via femoral artery access was performed with the goal of deferring stent placement, if possible. Diagnostic angiography revealed a dual-LAD system with an acute thrombotic occlusion of the lateral branch of the LAD at the origin of a previously placed stent in the proximal segment of the vessel with extension into the septal branch of the LAD (Fig. 3). After a discussion between the interventional cardiology, cardiac intensive care unit, and neurosurgical teams, there was a consensus to proceed with PCI. A lower-than-normal activated clotting time (ACT) target of 150–200 s was planned to balance the competing risks of catheter or wire-related thrombosis and intracerebral hemorrhage. The lesion was crossed with a guidewire and was dilated with a 2.5-mm balloon. Aspiration thrombectomy was then performed using the Indigo CAT Rx catheter (Penumbra, Alameda, CA) with subsequent dilation with a 3.0-mm non-compliant (NC) balloon resulting in resolution of the thrombus within the prior LAD stent (Fig. 4). Considering high risk of intraparenchymal brain hemorrhage associated with $P2Y_{12}$ inhibitor use in the immediate postoperative setting, no further intervention was performed with a plan for a staged completion of LAD PCI. The time from wire insertion in the LAD to equipment removal was 36 min, and actual ACT values ranged from 142 to 166 s.

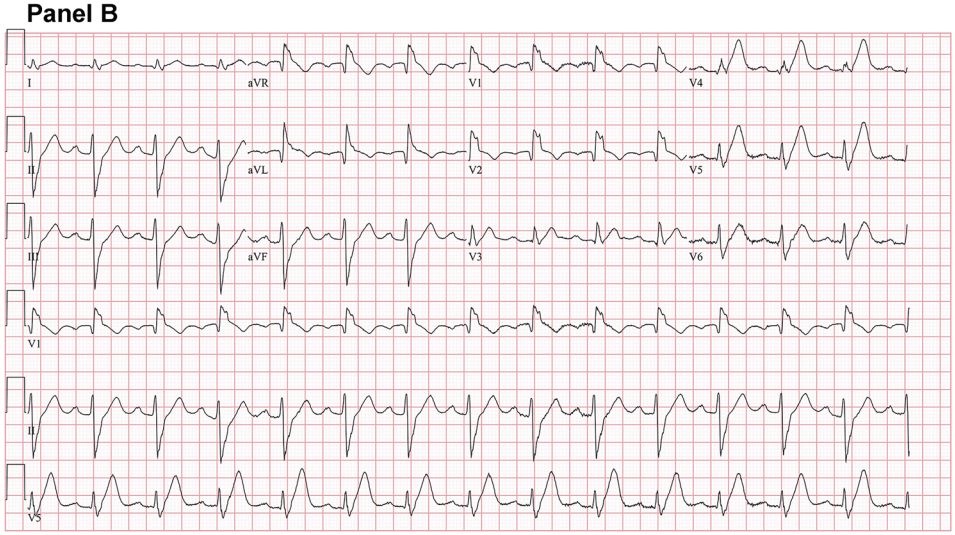
## Hospital Course

The patient returned to the cardiac intensive care unit for close neurologic and cardiac monitoring. Aspirin 81 mg daily monotherapy was continued. Interval cross-sectional computed tomography (CT) head imaging was

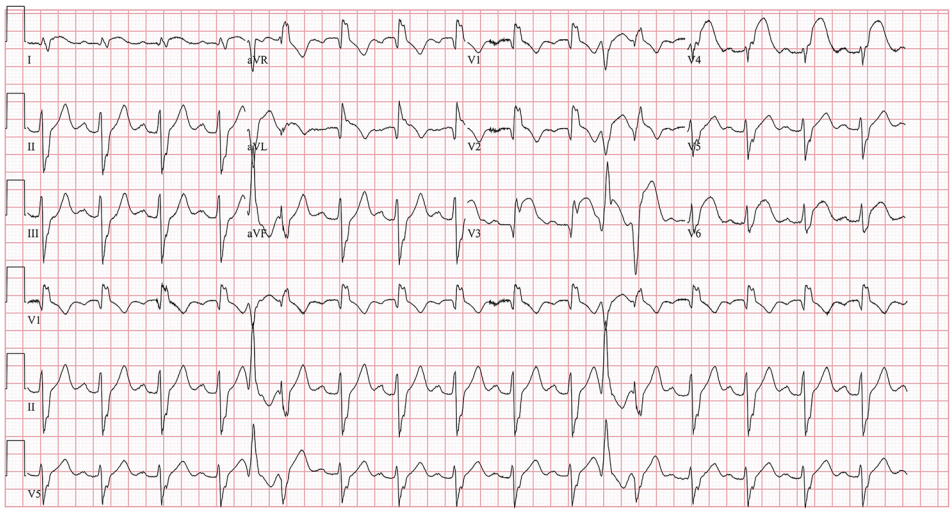
**Panel A**




**Panel B**




**Panel C**



◀**Fig. 2** Baseline and postoperative electrocardiograms (ECGs). Baseline ECG (panel A) showed sinus rhythm with a right bundle branch block. A postoperative ECG 1 h after symptom onset demonstrated a right bundle branch block with hyperacute T waves of the anterior and apical leads (panel B) which evolved into ST segment elevation of the anterior, apical, and lateral leads (panel C)

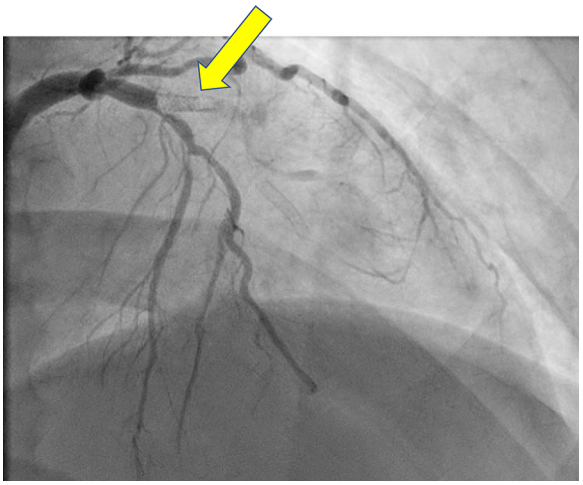


**Fig. 3** Diagnostic coronary angiography. Initial diagnostic coronary angiogram showing a dual-LAD (left anterior descending) system with a chronic total occlusion of the left circumflex artery and an acute thrombotic lesion at the origin of a previously placed stent in the proximal portion of the lateral LAD branch. The thrombus burden extended into the septal branch of the LAD which was jailed by the previously placed proximal LAD stent struts

performed every 8 h for the first day to screen for subclinical or preclinical bleeding that would require surgical evacuation. These studies demonstrated minimal bleeding in the surgical bed that remained stable on daily follow-up imaging over the next 2 days. He had no focal deficits on neurologic examination.

CYP2C19 genetic testing revealed a **1/*2* genotype which is an "intermediate metabolizer" phenotype. Baseline platelet aggregation studies were obtained on aspirin but before initiation of $P2Y_{12}$ inhibitor therapy. On day 10 postoperatively, clopidogrel 75 mg daily was initiated without a loading dose. To confirm adequate platelet inhibition prior to staged completion PCI, repeat platelet aggregation

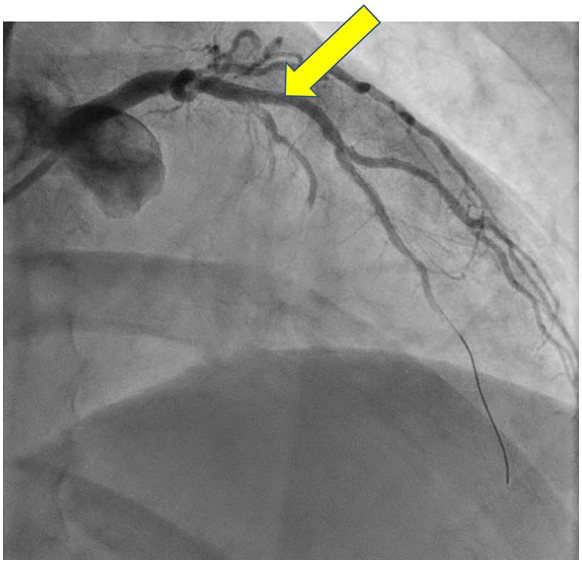


**Fig. 4** Coronary angiography following thrombectomy. Resolution of the acute thrombus following dilation, aspiration thrombectomy, and post-dilation. The no-reflow phenomenon was observed in the apical portion of the lateral left anterior descending (LAD) branch. Further intervention of the septal LAD branch was deferred because of the jailed origin and potential need for bifurcation stent placement in the immediate postoperative period

studies were performed after 5 days of clopidogrel 75 mg daily.

With adequate platelet inhibition confirmed (73% inhibition of platelet aggregation using ADP 20 μmol/L, Table 1), he underwent repeat coronary angiography with PCI on postoperative day 15. The previously placed LAD stent had remained patent following the initial aspiration thrombectomy and balloon dilation intervention (Fig. 5). There was TIMI 3 flow in the LAD. Intravascular ultrasound (IVUS) revealed underexpanded proximal and distal stents within the LAD as well as significant atherosclerosis in the intervening segments between the stents (Fig. 6). A 3.5 × 28 mm DES was placed to the mid-LAD and post-dilated with a 3.5-mm NC distally and a 4.0-mm NC at high pressure proximally. Post-intervention IVUS revealed a well-expanded and apposed stent without edge dissection (Fig. 7). There was TIMI 3 flow and no residual stenosis (Fig. 8). He was discharged home on postoperative day 17

**Table 1** Baseline and follow-up platelet aggregation studies

| | Baseline | Reference range | Follow-up* | Inhibition of baseline aggregation |
|---|---|---|---|---|
| Adenosine diphosphate (5 μM) | 70 | 60–94% | 18 | 74% |
| Adenosine diphosphate (20 μM) | 77 | 65–97% | 21 | 73% |
| Epinephrine | 51 | 60–95% | 9 | 82% |
| Collagen (0.19 mg/ml) | 83 | 65–94% | 17 | 80% |
| Collagen (0.38 mg/ml) | 79 | 55–90% | 65 | 18% |
| Arachidonic acid | 5 | 64–91% | 2 | 60% |
| Ristocetin (low) | 1 | 0–4% | 2 | − 100% |
| Ristocetin (high) | 86 | 60–100% | 78 | 9% |

Baseline platelet aggregation was normal in response to low and high dose adenosine diphosphate, low and high dose collagen, and low and high dose ristocetin with reduced response to arachidonic acid, consistent with aspirin effect. Follow-up platelet aggregation was reduced in response to low and high dose adenosine diphosphate, arachidonic acid, low dose collagen, and epinephrine, consistent with platelet inhibition due to aspirin and clopidogrel. Percentage inhibition of baseline aggregation was calculated as (Baseline aggregation % − Follow-up aggregation %)/Baseline aggregation %
*Follow-up study obtained after 5 daily doses of clopidogrel

and completed cardiac rehabilitation as an outpatient. The final pathology from the tumor resection revealed metastatic lung adenocarcinoma.

## DISCUSSION AND CLINICAL IMPLICATIONS

We describe a clinical scenario of a postoperative ST-elevation myocardial infarction 2 h following craniotomy with tumor resection treated with aspiration thrombectomy and balloon dilation followed by a staged completion PCI 15 days later following the gradual introduction of $P2Y_{12}$ inhibitor. To our knowledge, this staged approach has not been previously described, and it may provide temporizing therapy to patients with postoperative acute coronary syndrome at a high risk of bleeding until definitive revascularization can be completed.

Clopidogrel was selected as the preferred $P2Y_{12}$ agent in this case to minimize the risk of intracranial bleeding [5]. The risk of bleeding was balanced against the risk of stent thrombosis which is associated with carriage of a reduced-function CYP2C19 allele [6]. CYP2C19

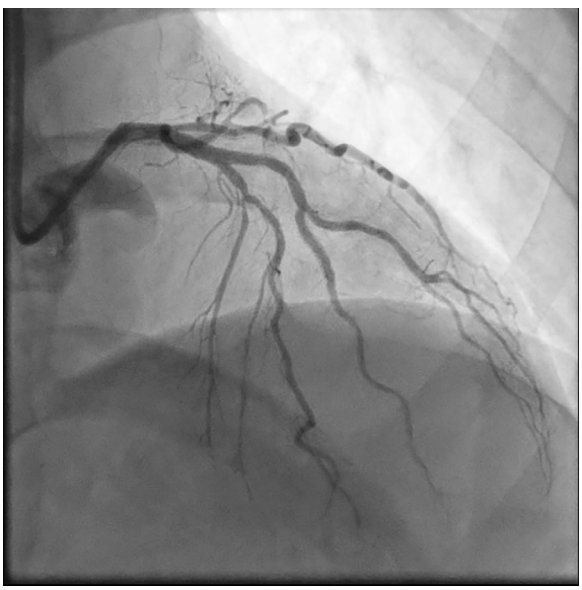


**Fig. 5** Follow-up diagnostic angiography. Repeat coronary angiography on postoperative day 15 revealed a patent left anterior descending (LAD) following aspiration thrombectomy and balloon angioplasty performed during the index angiography

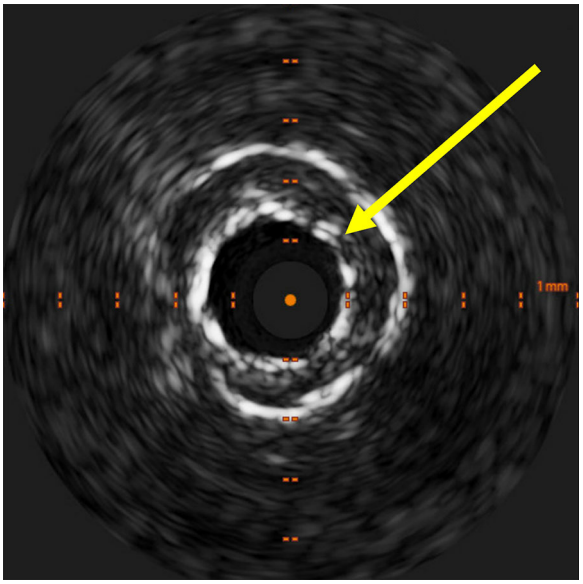



**Fig. 6** Intravascular ultrasound (IVUS) of underexpanded stent. IVUS at the time of the second procedure showed an underexpanded stent in the mid-LAD (left anterior descending). The prior stent (yellow arrow) had a diameter of 2.4 mm as compared to a vessel diameter of 4.0 mm

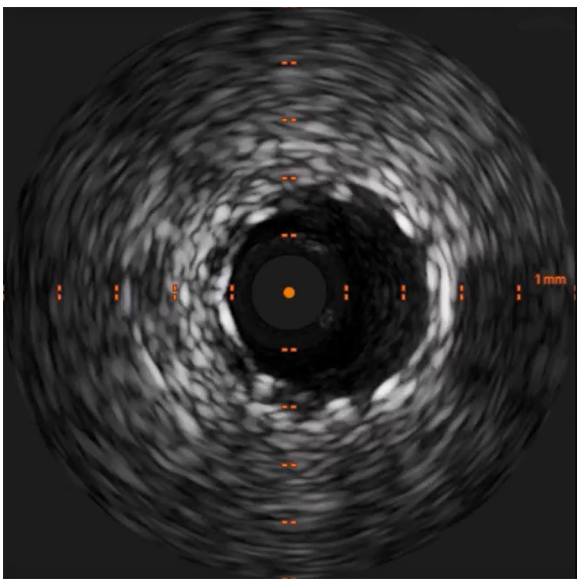



**Fig. 7** Post-intervention Intravascular ultrasound (IVUS). Post-intervention IVUS demonstrated a well-apposed and expanded stent without edge dissection

genetic testing was performed before the initiation of clopidogrel, identifying an intermediate metabolizer phenotype. Follow-up platelet

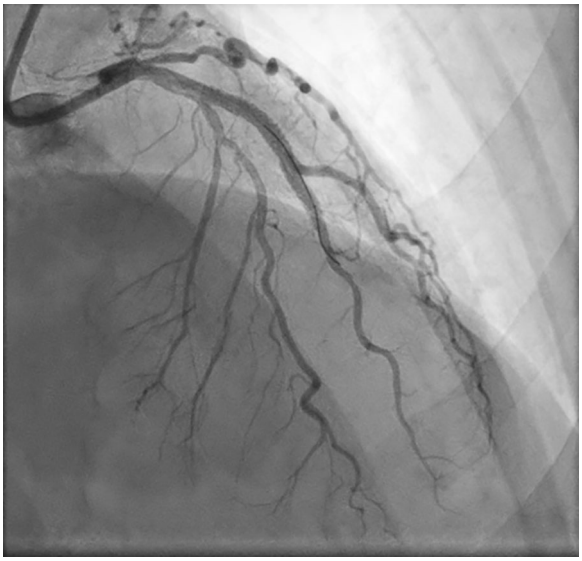


**Fig. 8** Coronary angiography following percutaneous coronary intervention (PCI) with drug-eluting stent (DES) placement. Staged PCI performed 15 days postoperatively revealed underexpanded proximal and distal stents within the left anterior descending (LAD). The proximal and distal stents were dilated and a new 3.5 × 28 mm Synergy DES was placed from the distal to proximal stents, overlapping both

aggregation studies were then performed to determine if sufficient platelet inhibition could be achieved with clopidogrel and aspirin therapy prior to proceeding with staged PCI. While CYP2C19 genotyping is not routinely performed in all patients with acute coronary syndromes undergoing PCI, selective testing—as performed in this case—may allow better risk quantification and stratification when competing risks are present.

There are conflicting data on the risks of postoperative intracranial bleeding in patients who continue aspirin in the perioperative period. One multicenter retrospective study reported a 2.6-fold increase in the rates of postoperative bleeding in patients undergoing open craniotomy for the repair of unruptured aneurysms who continued to take aspirin perioperatively [2]. A smaller single-center retrospective study showed no difference in bleeding complications for patients undergoing craniotomy with tumor resection who continued aspirin perioperatively [7].

The management of patients who do experience cardiovascular complications following neurosurgical procedures requires individualized risk–benefit analysis. There are limited human data for patients experiencing an acute thrombotic event to guide the safest timing of therapeutic anticoagulation resumption or initiation. An experimental animal model examining rats undergoing craniotomy and corticectomy identified a 30% rate of intracerebral hemorrhage in rats receiving therapeutic heparin (1.5–3 times control-activated partial thromboplastin time) on postoperative day 1 compared to a rate of 80% in rats receiving supratherapeutic (> 3 times control) doses of heparin [8]. A prior review of perioperative anticoagulation management in neurosurgery concluded that therapeutic anticoagulation can be initiated 3–5 days following neurosurgery in patients at the highest risk of thromboembolic events [9].

Patients with cancer face an elevated risk of developing cardiovascular complications, including higher morbidity and mortality associated with coronary artery disease [10–12]. Specifically, managing acute coronary syndrome (ACS) in patients with cancer and in the perioperative setting presents unique challenges due to their multiple comorbidities and increased bleeding risk. Additionally, the prognosis of these patients when undergoing invasive procedures for ACS is influenced by factors such as cancer type, staging, time since diagnosis, and ongoing oncological treatment [13–15]. Growing evidence shows that patients with cancer have worse in-hospital outcomes post-PCI with increased rates of major adverse cardiovascular events, 90-day readmission, and bleeding complications [11, 13, 16–18]. Long-term data showed a twofold higher rate of MI and repeat vascularization and a nearly threefold higher rate of stent thrombosis over 5 years post-PCI in patients with cancer [19].

The decision to pursue conservative medical management or an invasive strategy for patients with cancer and ACS is complex. It requires an individualized approach weighing the inherent risks of coronary revascularization procedures and the use of antiplatelets, guided by genetic testing when feasible. In 2016, the Society for Cardiovascular Angiography and Interventions (SCAI) issued a consensus document addressing special considerations of cardio-oncology patients in the cardiac catheterization laboratory, with respect to thrombocytopenia, coagulopathies, bleeding tendencies, vascular access complications, and increased stent thrombosis risk [20]. However, the management of ACS in this high-risk population needs more specific evidence-based guidelines calling for multidisciplinary collaboration and further research efforts to improve outcomes in cardio-oncology patients.

***Author Contributions.*** Dr. Curtis Ginder, Dr. Giselle Suero-Abreu, and Dr. Robert Giugliano created the concept and design of the manuscript. Dr. Curtis Ginder, Dr. Giselle Suero-Abreu, Dr. Saad Ghumman, Dr. Brian Bergmark, Dr. Omar Arnaout, and Dr. Robert Giugliano drafted, edited, and revised the manuscript.

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## *Declarations*

***Conflict of Interest.*** Dr. Bergmark has received institutional research grant support through Brigham and Women's Hospital from Pfizer, Ionis, AstraZeneca, Philips, Abbott Vascular, SpectraWAVE, and Inari. Dr. Bergmark reports consulting fees from Abiomed, Abbott Vascular, Bain Life Sciences, Endovascular Engineering, Terumo, and SpectraWAVE. Dr. Giugliano receives clinical trial and research support from Amgen, Anthos Therapeutics, Daiichi-Sankyo, and Ionis; honoraria for lectures or the continuing medical education program from Amgen, Centrix, Daiichi-Sankyo, Dr. Reddy's Laboratories, Medical Education Resources, Medscape, Menarini, Merck, Pfizer, SAJA Pharmaceuticals, Servier, Shanghai Medical Telescope, and Voxmedia; and is a consultant for Amarin, Amgen, Bayer, Boston

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***Ethical Approval.*** The patient presented in this case report granted written informed consent and permission for publication of his clinical course.



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