The Heart Surgery Forum #1998-7137
1 (1):54–59, 1998

Online address: www.hsforum.com/vol1/issue1/1998-7137.html

The "T-MIDCAB" Procedure. Use of Extension Grafts from the Undisturbed Internal Mammary Artery in High-Risk Patients

Dr. Coulson

(#1998–7137 ... May 29, 1998)

A.S. Coulson, MD, PhD and S.A. Bakhshay, MD

Dameron Heart Institute, Stockton, CA, USA

ABSTRACT

Background: Minimally invasive direct coronary artery bypass (MIDCAB) grafting is an attractive new alternative for revascularizing patients with high perioperative risk for standard coronary surgery. However, limited surgical exposure through a small thoracotomy makes harvesting the full length of the internal mammary artery (IMA) very difficult and time consuming. We are now employing a new alternative with a "T" shaped bridge graft constructed from the undisturbed IMA using a 4 centimeter interposition segment of donor vessel. We prefer this approach in high risk cases in order to reduce the trauma of the thoracotomy, minimize pain and narcotic use, promote early extubation, and achieve immediate post-operative mobilization and recovery in patients who would otherwise be at risk for a poor outcome with conventional grafting techniques.

Methods: From September 10, 1997 to December 19, 1997 eight high-risk patients underwent at least one "T-MIDCAB" graft from the undisturbed IMA to the coronary artery using a short segment of either radial artery or saphenous vein. All cases were performed using a limited access anterior thoracotomy through the bed of the resected costal cartilage and without intercostal retraction. Five males and three females ranging from 58 to 83 years (average 73 years) were operated using this new concept. Preoperative ejection fractions ranged from 25% to 80% (mean 43%). Parsonnet scores ranged from 21 to 43 (average 34) with predicted mortalities ranging from 30% to 40%.

Results: Eleven "T" grafts were placed (1.38 distals/patient). All 8 patients survived. Postoperative complications were minimal. The average length of stay was only 8 days (range 3 to 9 days). Intensive care unit stay averaged 3 days (range 1 to 4 days). One patient underwent postoperative angiography which demonstrated full patency of the conduit and all anastomoses.

Conclusions: "T-MIDCAB" using a bridge graft of free radial artery or saphenous vein appears to be successful in high-risk patients. The authors noted shorter operative times, reduced chest wall trauma and better pain control than with standard MIDCAB and full IMA harvesting. Cautious use of this procedure as an alternative to more morbid types of surgical revascularization is advised.

INTRODUCTION

Surgical revascularization in high-risk patients is becoming more and more common. Parsonnet attempted to stratify perioperative risk and predicted mortality based on the presence or absence of major comorbid states such as cerebral vascular disease, renal failure, etc. Elevated Parsonnet scores are associated with higher perioperative mortality, morbidity, and length of stay [Parsonnet 1989].

Less invasive procedures for surgical revascularization of the left ventricle are being proposed as a means of reducing operative trauma and the sequelae of cardiopulmonary bypass (CPB) [Westaby 1996, Coulson 1998]. These new strategies attempt to reduce the magnitude of wound trauma and thus perioperative pain, immobility, and nosocomial side effects. By avoiding heart-lung bypass, an additional protection against cerebrovascular, renal, and bleeding complications is possible. However, not all minimally invasive coronary operations are performed with reduced surgical trauma. Lateral thoracotomies can be quite painful even if small in length. Injury to the intercostal nerve can cause very significant pain, splinting, hypoventilation, and respiratory compromise. Full mobilization of the internal mammary artery (IMA) through a limited access thoracotomy is difficult and time consuming. Commercial chest wall retractors will provide additional exposure to the IMA, but at the expense of considerable traction on the thoracic cage. This type of invasion makes these MIDCAB painful and traumatic despite the attractive eponym coined for the procedure.

In order to reduce the magnitude of the surgical incision and dissection needed for MIDCAB, we have utilized a tech-

Address correspondence and reprint requests to A.S. Coulson, MD, Linacia Building, 420 West Acacia St., Suite 12, Stockton, CA 95203

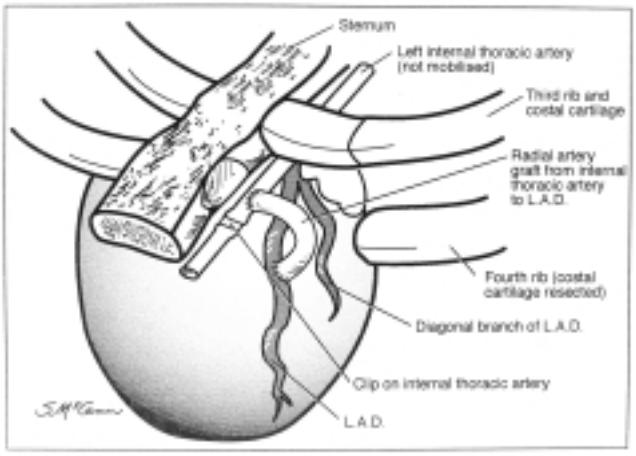

Figure 1. Diagram illustrating the "T-MIDCAB" technique. The IMA is not mobilized or dissected in any way.

nical alternative which allows us to quickly perform revascularization on selected target vessels even in the most difficult patients. The "T-MIDCAB" procedure is peformed by grafting a short segment of donor vessel (either radial artery or saphenous vein) between the undisturbed IMA and the target coronary artery. Special exposure techniques are used to minimize chest wall retraction and avoid injury to the intercostal nerve. Since the IMA is not mobilized outside of the intercostal space of entry, the procedure is of limited trauma and easily performed in a short operative time. A similar procedure using the inferior epigastric artery as a donor graft was recently reported by Cohn et al. [Cohn 1998]. In this current publication, we report our initial experience with 8 consecutive high-risk patients and discuss the advantages offered by this novel approach.

MATERIALS AND METHODS

Surgical Technique

For a demonstration of the "T-MIDCAB" technique see Figure 1, ◎. We routinely use a double-lumen endotracheal tube and pace-port Swan-Ganz catheter [Coulson 1997, Coulson 1998]. The thoracotomy was kept small and centered over the fourth costal cartilage on the left or the fifth cartilage on the right. The Harmonic Scalpel was used to reduce pain by avoiding the trauma and heat typical of electrocautery [Coulson 1997]. Mechanical rib spreaders were not used. Instead, soft tissues were simply held back with Weitlander self-retaining retractors. After removal of the costal cartilage, the IMA was located and preserved in its bed. The edges of the incised pericardium were retracted with heavy sutures to facilitate exposure of the target coronary artery. Simultaneous to the thoracotomy, an assistant harvested the donor vessel (radial artery or saphenous vein) for a distance of 8 to 10 centimeters. Radial conduits were removed with a surrounding 4 millimeter wide perivascular pedicle to reduce trauma to the arterial wall. Free RA grafts were pretreated with papaverine and stored in Plasmanate solution.

Proximal and distal sutures with snares were used to maintain a blood free operative field after opening the coronary artery. Silastic Meditapes were sometimes used for additional presentation of the coronary. When possible, we perfused the distal coronary with an intraluminal shunt device coupled to a femoral artery cannula as reported previously [Coulson 1998]. This maneuver reduces arrythmias and hypotension during coronary occlusion on the beating heart. Preconditioning was not used.

Regional stabilization of the target coronary artery was achieved with a commerical stabilizer (Estech Universal Stabilizer, Estech, Danville, CA). The flexible arm of this device was not anchored to an intercostal retractor but rather to a crossbar attached to the operating table (see Figure 2, ◎). This maneuver is in keeping with our goal to avoid any trauma to the intercostal nerve. If additional soft tissue or diaphragm retraction was needed, the Omni-Tract¨ device was used.

For construction of the "T" bridge graft, the distal anastomosis to the coronary artery was always performed first. Interrupted 7–0 polypropylene suture was preferred. Vision was assisted by a commercial CO_2 blower. After completion of the distal anastomosis, hemostasis was always secured before proceeding with the proximal anastomosis. Then the lungs were maximally inflated to determine the optimum length of the donor graft. The ipsilateral IMA was separated from the vena commicantes and controlled with disposable vascular clips (Scanlan Instruments). The donor conduit was beveled and sutured to a linear arteriotomy in the intact IMA using interrupted sutures and taking wide bites of the surrounding perivascular soft tissues to minimize the risk of stenosis in the postoperative period. Graft patency was confirmed by flow measurements using the Cliniflow II probe (Carolina Medical Electronics, Inc., King, North Carolina).

Closure of the thoracotomy wound was also modified with specific attention towards pain control. To achieve this goal, the authors performed selective denervation by resection of the distal portion of intercostal nerves 3 and 4 on the left side or 4 and 5 on the right side. The intercostal space was then injected with bupivicaine solution and the soft tissues covered over the bed of the resected cartilage. Wound drainage was performed with a single Jackson-Pratt silicone drain which was later used for postoperative bupivicaine injections.

Patient Data

In our center, all patients are graded using the Parsonnet System of Uniform Stratification of Risk [Parsonnet 1989]. Our report consists of a retrospective analysis of eight patients with high Parsonnet scores and predicted operative mortality who were referred for MIDCAB surgery. All eight patients demonstrated significant preoperative comorbidities (see Table 1) including one patient with hepatic coma and a GI bleed, another with a massive preoperative stroke and another with von Willebrand's disease. Two patients had suffered significant preoperative acute myocardial infarctions, one following a lower

Table 1

#	Sex	Age	EF (%)	Comorbidities	Parsonnet Score
1	M	78	50	Redo, acute MI, blocked carotid	29
2	F	68	25	Obese, smoker, severe COPD	21
3	F	73	30	Obese, blind, diabetic, gangrene	24
4	M	82	50	Redo, syphilis, blocked carotid	38
5	M	74	25	Seizures, stroke, smoker, pacemaker, mitral regurgitation	36
6	M	70	40	Acute MI, delerium tremens, hepatic coma, gastrointestinal bleed, mitral regurgitation	42
7	M	58	80	Massive stroke, smoker, blocked carotids	28
8	F	83	44	Von Willebrands, congestive heart failure, mitral regurgitation	43

extremity amputation. Two other patients had undergone previous cardiac surgery.

"T-MIDCAB" was performed on eight patients (see Table 2) with a total of 11 distal grafts placed (1.38 distals per patient). Two other types of coronary graft were also used in two of the eight patients (see Table 2) for a total of 1.6 grafts per patient in the whole series. There were five males and three females with ages ranging from 58 to 83 years (average 73 years).

Table 2 lists the specifics of the grafts that were placed in each patient. There was a total of seven LIMA to RA to LAD grafts, three RIMA to RA to RCA/PDA grafts, one RIMA to SV to PDA graft, and one thoracic aorta to RA to the first marginal branch of the circumflex.

Patient #5 (see Table 2) also underwent placement of a DDD pacemaker at the same operation while patient #6 had a thoracic aorta to circumflex graft using the RA. In the case of patient #2 (see Table 2), the left IMA easily reached the LAD target site with a minimum of dissection so an RA graft was not used in this particular case. On the right side of this same patient, saphenous vein had to be used because of preoperative concerns about arm ischemia.

Before completion of the RA-IMA anastomosis, pressures were measured simultaneously in the IMA and the RA graft attached to the coronary artery. After completion of the bridge graft segment, flows were measured using a flow probe (Cliniflow II, Carolina Medical Electronics, Inc., King, North Carolina).

Pain Control

Intraoperative and postoperative pain was minimized by avoiding any type of chest wall retraction or any pressure on the thoracic surgical window. In addition, the distal ends of the left third and fourth intercostal nerves and/or the right fourth and fifth intercostal nerves were removed. A pain catheter was placed in the soft tissues to permit the administration of bupivacaine intraoperatively and at regular intervals for 48 hours postoperatively [Borgess, 1998]. The pain control catheter consisted of a modified Jackson-Pratt drain with an antimicrobial filter through which 15 cc of 0.25% plain bupivacaine was injected.

RESULTS

Despite predicted mortality rates of 30% to 40% by Parsonnet stratification, all eight patients survived. Thirty day hospital mortality was zero. Postoperative complications were minimal (see Table 3). Radial artery grafts were harvested in seven of the eight patients and no patient experienced hand ischemia. Clinically, all patients were relieved of their angina symptoms and had no further cardiac problems. The length of stay in the intensive care unit averaged 3 days (range 1 to 4 days). The total hospital stay averaged 8 days (range 3 to 9 days).

In the followup period, patient #1 was readmitted for a hybrid angioplasty of an old saphenous vein graft to the right coronary artery . His LAD bridge graft was restudied at that time and found to be widely patent with good flows (see Figure 3, ◎). Patient #2 was readmitted for renal artery stenting. Patient #3 had a paranoid reaction in addition to an infection of a right below-knee amputation stump. Patient #4 was readmitted with a deep vein thrombosis. Patient #5 required pacemaker reprogramming in the postoperative period. Patient #6 was confused and combative for a few days and his bilirubin rose to a maximum of 1.8 mg/%.

Table 2. Graft Results

Patient	Grafts	Flows (cc/min)
1	LIMA-RA-LAD	150 cc/min
2	(a) LIMA-LAD	Not done
	(b) RIMA-SV-PDA	
3	(a) RIMA-RA-RCA	Not done
	(b) LIMA-RA-LAD	
4	(a) LIMA-RA-LAD	192 cc/min
	(b) RIMA-RA-PDA	182 cc/min
5	LIMA-RA-LAD	186 cc/min
6	(a) LIMA-RA-LAD	49 cc/min
	(b) Thoracic Ao-RA-OM1	59 cc/min
7	LIMA-RA-LAD	80 cc/min
8	(a) LIMA-RA-LAD	168 cc/min
	(b) RIMA-RA-RCA	254 cc/min

Table 3. Patient Results

Patient	Post Operative Complications	Length of Stay (Days) ICU	Total
1	Readmit for hybrid angioplatsy of old SV graft to RCA	2	3
2	Readmit renal artery stenting	3	7
3	Paranoid reaction, infected amputations stump	3	9
4	Readmit for Deep Venous Thrombosis	4	7
5	Reprogramming of pacemaker	3	4
6	Confused, combative, bilirubin 1.8	4	7
7	None	1	3
8	Family would not take home until after Christmas	4	7

Figure 4 (◎) shows simultaneous recordings made of pressures in the LIMA and in the RA graft sutured to the LAD. It can be seen that the pressures in the LIMA are consistently higher than in the coronary artery graft for most of the cardiac cycle. All such grafts had good intraoperative flows (although flows were not measured in two cases). The flows averaged 136 cc per minute (49 to 254 cc per minute). The bupivacaine administration catheters were left in place for 48 hours, and the ICU personnel were impressed with the minimal chest wall pain experienced by the patients and the minimal amounts of analgesics required in the postoperative period.

DISCUSSION

Less invasive surgical approaches to the heart have revolutionized the current practice of cardiac surgery. Small incisions, avoidance of sternotomy, avoidance of cardiopulmonary bypass, and a general trend towards reduced surgical trauma have modernized the practice of our specialty. Unfortunately not all procedures labeled as less invasive are actually less traumatic to the patient. Post thoracotomy pain is a major problem with any intercostal incision. By switching away from sternotomy, MIDCAB surgeons have revisited the known problems of thoracotomy, particularly post-thoractomy pain, splinting, hypoventilation, and the side effects of pain management. In order for less invasive cardiac procedures to become universally accepted (by surgeons and patients alike), refinements are needed.

We have recently faced a subset of very ill, high-risk patients in our practice for whom standard coronary bypass would have been too morbid. At the same time, we felt that MIDCAB with full retraction and harvesting of the mammary artery would lead to significant chest wall trauma and other morbidity. Thus, we redesigned our MIDCAB approach with the goal to eliminate the painful sequelae of thoracotomy and the severe retraction needed to harvest a full length of IMA . By doing so, we have been able to achieve uniform survival and short ICU stays in a group of patients with very high predicted mortality and morbidity.

The principle differences between the "T-MIDCAB" and the MIDCAB procedures reported previously are: 1) the internal mammary artery remains undissected, and 2) the chest wall is not retracted. When the IMA is allowed to remain in its native bed undisturbed, grafting of anterior or inferior wall targets can still be performed through a very small thoracotomy using an extension graft. We have achieved this in eight patients by resection of the costal cartilages and avoidance of any mechanical retractors inside the intercostal space. This allowed us to accomplish our goal without crushing or stretching of the intercostal nerves, a maneuver known to cause both early and late pain syndromes. An essential component of our technique was the use of a stabilizer which could be fixed to an external support bar well outside of the surgical wound (Estech Universal Stabilizer, Estech, Danville, CA). Pain control was further improved by bupivicaine injections into the wound drain and resection of the tips of the intercostal nerves. Although we did not perform any formal pain studies, the nursing staff confirmed our impressions that pain control was excellent in all these cases. We attribute our modest length of ICU stay to reduced splinting and hypoventilation, reduced need for narcotics, earlier extubation, and immediate mobilization of these patients.

We prefer to use radial artery as our extension conduit. The radial artery is easy to harvest and to sew to both the

Figure 3. Angiogram of patient #1, showing good flow from the in situ IMA through an RA bridge graft to the LAD. The sternal wires were placed during a previous surgery 12 years earlier.

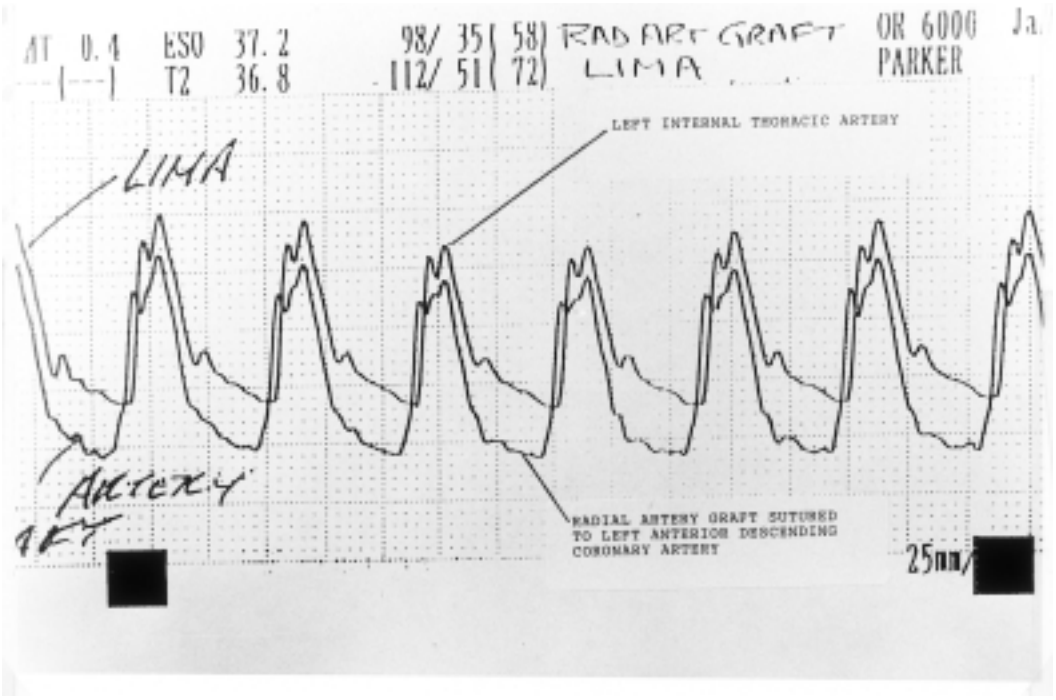

Figure 4. Simultaneous recording of pressures in the LIMA and in the RA graft sutured to the LAD. The pressure in the LIMA is consistently higher than in the coronary artery graft for most of the cardiac cycle.

donor IMA and the coronary artery. By performing the distal anastomosis first, it is possible to maneuver the donor graft in all directions while suturing to the coronary edges. This facilitates clear exposure to the entire anastomosis and each individual suture. Bridge grafting also removes the risk of the donor vessel being too short with either stretching or avulsion after completion of the graft. By inflating the lungs prior to sizing the graft, we are assured of adequate length and freedom from kinking or tethering.

Initially we were concerned that a simple extension graft from the intact IMA could cause a coronary steal syndrome. This has not been observed in any case. Using direct pressure measurements in both the IMA and the bridge segment, we have confirmed that perfusion pressure is always higher in the IMA, thus elminating any possibility of a coronary steal phenomenon.

The use of the radial artery for coronary grafting does have a checkered past. In the mid-1970s several centers used the radial artery for coronary bypass and reported long term patency rates of only 30% to 50% [Chiu 1976, Grooters 1994]. However, recent changes in harvesting, handling, and vasospasm management are credited with improved results. Calafiore, et al. achieved a 94.3% angiographic patency at a minimum of 12 months follow-up in 35 radial artery IMA extension grafts performed through sternotomy. [Calafiore 1995]. At present we have had the occasion to angiogram only one postoperative "T-MIDCAB" patient which confirmed full patency of the conduit and all anastomoses. Our use of the RA extension graft parallels the extension technique of Calafiore so closely that we anticipate similar patency rates over time. As of this writing, we have not needed to reoperate on any of the "T-MIDCAB" patient. Nonetheless, we believe there is adequate length in the completed bridge graft that transsternal reoperation should pose no threat to the anastomosis. In addition, since the pericardium is mostly intact, reentery should be safe and with minimal lysis of adhesions needed for cannulation and cardiopulmonary bypass.

In summary, we have obtained excellent short-term (1 to 3 months) survival and angina relief by using a "T" bridge graft from the undisturbed IMA to the coronary artery. There was no mortality, minimum morbidity, and a short length of intensive care stay. By avoiding IMA harvesting and chest wall trauma, we found it possible to revascularize important anterior or inferior targets with minimal wound trauma, pain, and postoperative dysfunction. Although our initial series is small and the postoperative followup is only a few months, the technique seems to be a promising one for revascularizing high risk patients with multiple comorbidities. More time will be required to determine what the clinical role of this procedure is. We plan to continue this approach when indicated and attempt to confirm graft patency rates with angiography whenever possible.

REFERENCES

1. Borgess MF and Coulson AS: Minimally Invasive Coronary Bypass Surgery. Postoperative Pain Management Using Intermittent Bupivacaine Infiltration. Brit J Anesth 80:519-20, 1998.
2. Calafiore AM, DiGiammarco G,Teodori G. Radial artery and inferior epigastric artery as composite graft with the IMA: improved midterm angiographic results. Ann Thorac Surg 60:

517–524, 1995.
3. Chiu CJ. Why do radial artery grafts for aortocoronary bypass fail? A reappraisal. Ann Thorac Surg 22:520–523, 1976.
4. Cohn WE, Suen HC, Weintraub RM, Johnson RG. The "H" graft: an alternative approach for performing minimally invasive direct coronary artery bypass. J Thorac Cardiovasc Surg 115(1): 148–151, Jan 1998.
5. Coulson AS, Bakhshay SA, Quarnstrom J, Mayer S, Holmes K, Villarreal M: Minimally Invasive Direct Coronary Artery Bypass Surgery. AORN Journal 66:1012–37, 1997.
6. Coulson AS, Bakhshay SA: The Use of the Harmonic Scalpel in Minimally Invasive Coronary Artery Bypass Surgery. Surgical Rounds 20:52–56, 1997.
7. Coulson AS, Bakhshay SA, Quarnstrom J, Spohn P: Temporary Coronary Artery Perfusion Catheter During Minimally Invasive Coronary Surgery. Chest 113:514–20, 1998.
8. Coulson AS: Minimally Invasive Coronary Artery Surgery. J Thorac Cardiovasc Surg 115:486–7, 1998.
9. Grooters RK and Nishida H. The radial artery. Chapter 8 (pages 83–88) in Alternative Bypass Conduits and Methods for Surgical Revascularization. Futura Publishing Company, Inc. Armonk, NY.
10. Parsonnet V, Dean D, Bernstein AD: A Method of Uniform Stratification of Risk for Evaluating the Results of Surgery in Acquired Adult Heart Disease. Circulation (sup I) 79;I-3 to I-12, 1989.
11. Westaby S and Benetti FJ. Less invasive coronary surgery: consensus from the Oxford meeting. Ann Thorac Surg 62 (3):924–31, Sept 1996.

REVIEW AND COMMENTARY

1. Editorial Board Member SC389 writes:

I think that this is a very innovative technique in very high-risk patients and I congratulate the author on a clear detailed description of his technique.

1. Was the pleura entered or was the surgery performed extrapleurally as the drain is used later for pain control and I was wondering if there is a risk of a pneumothorax.

2. I understand that these were very high-risk patients and obviously survived. I am concerned about the life expectancy of a patient in hepatic coma and another with a massive stroke and whether any surgery was indicated in these patients.

Authors' Response by A.S. Coulson, MD:

1. The pleura was entered and a chest tube inserted.

2. The indications for this approach initially were for very sick patients with a high Parsonnet score. I think now because of its technical simplicity, the indications are expanding to patients who are not quite so sick.

With regard to the hepatic coma and GI bleed, this patient had recovered recently from the hepatic coma and GI bleed. He was seven days after the massive GI bleed and hepatic coma. So, I guess the correct phrase here would be "recovering from hepatic coma and GI bleed." He needed to undergo the bypass surgery because of ST changes and unremitting chest pain.