

Research Article

Implementation and Challenges of Establishing a Multi-Disciplinary Heart and Vascular Emergency System

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Abstract

Background

We developed a regionalized protocol at The Ohio State University Wexner Medical Center (OSUWMC) in order to improve outcomes of acute cardiac and vascular conditions by streamlining diagnosis, transport, and treatment through a team of coordinated multidisciplinary providers. In this manuscript, we discuss the challenges to implementation of our system, early outcomes of our protocol driven triage system and insights into barriers of adopting this in other institutions.

Method and Results

A multi-disciplinary team developed an algorithm to guide initial management, arrival, diagnosis and operative repair in patients with acute limb ischemia, ruptured aortic aneurysm, and acute aortic dissection. We recorded prospective data on number of referrals, time to treatment, in-hospital mortality, and length of stay from April, 2012 to October, 2014.

92 patients were referred for acute thoracic aortic dissections (AAD), 50 of which were operative. In-hospital mortality for AAD ranged from 12-18% since the program's implementation. 38 patients were referred for ruptured aortic aneurysm (rAA); 25 received intervention and in-hospital mortality was 34%. 54 patients were referred for acute limb ischemia (ALI), and the limb salvage rate was 96% and in-hospital mortality was 9% since the program's implementation.

Conclusion

Challenges to implementation included activation of the protocol, discouraging use of protocol for non-cardiovascular emergencies, optimizing diagnostic criteria and expedient treatment, and understanding how implementation affect the all of the providers involved. In future studies, we will compare/contrast our findings from before and after implementation of the regionalized protocol.

Keywords: Aortic Dissection; Acute Limb Ischemia, Cardiovascular Emergencies

Abbreviation

AAD: Acute Thoracic Aortic Dissections;

ALI: Acute Limb Ischemia;

STEMI: ST-Elevation Myocardial Infarction;

rAA: Ruptured Aortic Aneurysm;

ER: Emergency Room

Introduction

There is increasing evidence that early recognition, diagnosis and time to intervention correlates with significantly improved survival and outcomes in cardiovascular emergencies [1,2]. Indeed, regionalization and activation of designated trauma centers has reduced mortality by nearly 20% in designated centers [2]. Likewise, improvements in both the time to reperfusion and a theoretical decrease in mortality rates has been highlighted by various state and national ST-elevation myocardial infarction (STEMI) protocols [3]. Experiences with both regionalization and improvements in care have led some to postulate that there is a need for a national cardiovascular emergency care system [4]. We chose to implement an expansion to our already existing STEMI program to include a regional cardiovascular emergency program including a multi-disciplinary approach to acute aortic dissection (AAD), acute limb ischemia (ALI) and ruptured aortic aneurysm (rAA).

Conception

The Level One Heart and Vascular Emergency Program was created to improve outcomes of acute cardiac and vascular conditions by streamlining diagnosis, transport, and treatment, and managing care through a dedicated team of coordinated interdisciplinary providers. A multispecialty committee including cardiologists, cardiothoracic surgeons, vascular surgeons, emergency medicine physicians, and cardiovascular nurses convened to construct protocols of care from the time of referring hospital diagnosis through definitive treatment at our tertiary care hospital for the diagnoses of acute aortic dissection, ruptured abdominal aortic aneurysm, and acute limb ischemia.

The concept of our program was based on existing models at Vanderbilt University Medical Center, Methodist Hospital of Indianapolis, and Minneapolis Heart Institute Foundation at Abbott—Northwestern Hospital. In conjunction with interviews and visits to these sites and our own experience with our institutional STEMI program that was initiated in 2009, we conceived and developed the regional Level One center over a period of 18 months from conception to activation.

The activation protocol began with a toll free phone number as a universal access to the program regardless of diagnosis as to facilitate rapid transportation and confirmation of

diagnosis (Figure 1). Prior to implementation, referral patterns and mechanisms were variable and accepting physician-specific. Additionally, there was a great deal of variability amongst the physicians with diagnostic imaging, resuscitative care, and logistics of mobilizing the operating room team. Specific goals of the program included decreasing time from diagnosis to definitive management in these time-sensitive diagnoses, standardizing appropriate evidenced-based testing and resuscitative care, improving logistical coordination between involved units including Emergency Medical Services, Emergency Department, physicians (community and tertiary), operating room staff and nursing.

The program was officially started in April of 2012 with a period of consumer and referring facility and physician targeted marketing. Details of each referral to the program were recorded prospectively. The collected data and medical records of all patients referred to the Program from inception through October 2014 were reviewed with the approval of The Ohio State University Institutional Review Board.

Implementation

Three months after the initiation of our protocol, a 31 year old male with a history of hypertension, woke up with sudden onset chest pain that radiated to his left arm and left back. He subsequently developed left lower extremity paralysis and sought medical help at an outside hospital. The referring site's imaging studies confirmed a type A aortic dissection and our Level 1 program was contacted for immediate air flight transfer. Additionally, we were able to consult in real time for initiation of intravenous esmolol as the systolic blood pressure was 220 mm Hg during the initial phone call. Upon arrival, he was met in the emergency room (ER) by the attending emergency room staff, the cardiac anesthesia team as well as the cardiac surgeon. Within seven minutes of arrival to our ER, a review of the available imaging confirmed a complex dissection involving his arch with near complete obstruction of his right carotid artery, and he was taken to the operating room. Subsequently, he underwent a replacement of his aorta under hypothermic circulatory arrest. Post-operatively, he regained full neurologic recovery and was discharged home on post-operative day number fourteen highlighting the impact of the program within our institution.

Results

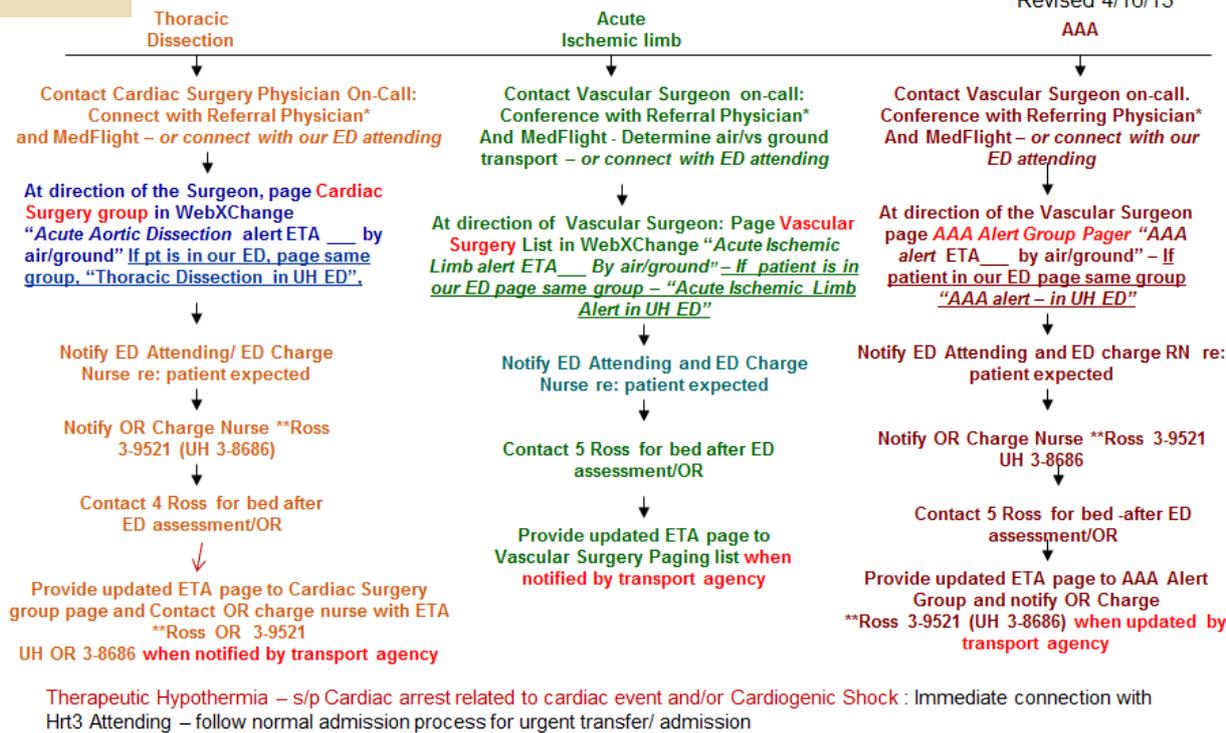
Prior to the program's implementation, there was a period of outreach programs and online advertising announcing the start of our Level 1 program. In total between April 2012 and October 2014, we have had 235 Level 1 program activations. 193 (82%) patients were referred from outside hospitals, and 6 patients from out-of-state. Most of our cases originated from the surrounding communities of central Ohio (Figure 2,3).

Acute Aortic Dissections

92 patients were referred to our center for acute thoracic aortic dissections (60—type A, 27—type B, 5—mixed).

Level 1 Heart and Vascular Emergency Program – 366-8111

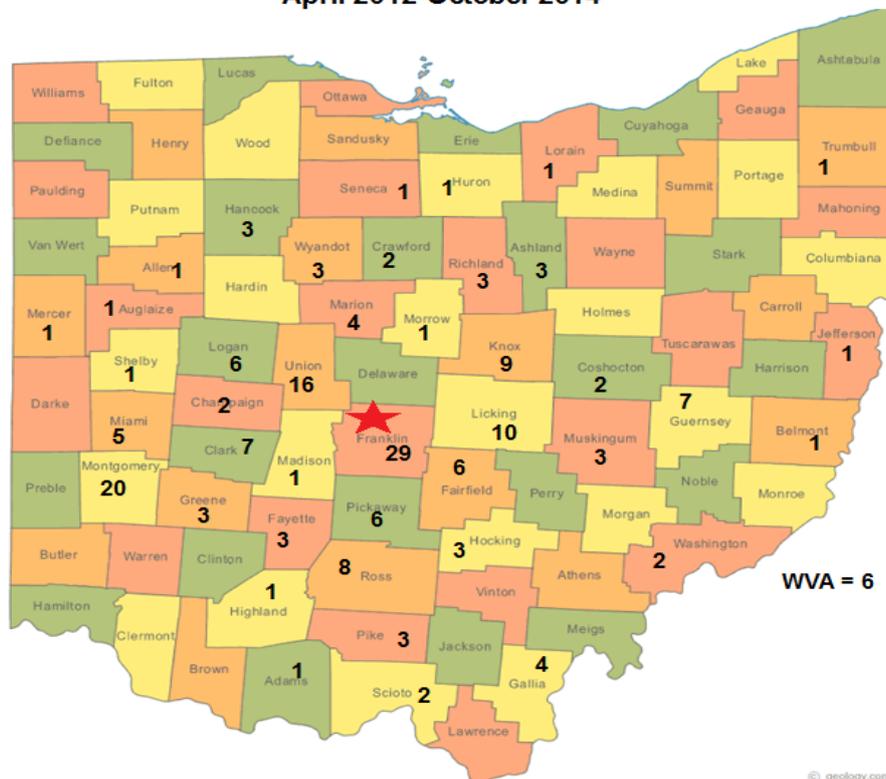
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Transfer Center may receive hotline calls and will facilitate immediate consultation with Thoracic/ Vascular Surgery for external physicians, our own ED or any internal OSU physician.

Figure 1. Flow diagram displaying protocol outline in patients with AAD, ALI, AAA.

Level One Program Transfers April 2012-October 2014



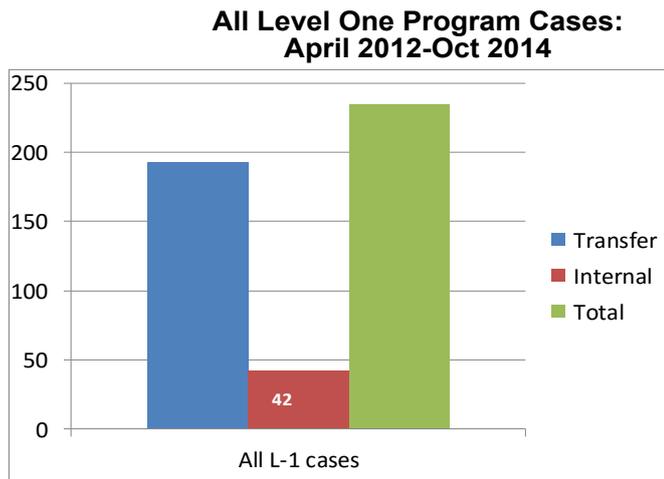


Figure 3. Graph represents case volume from referral vs internal admissions for Level 1 cases.

The majority of the patients 79 (86%) were transferred from outside facilities. Among type A dissection patients undergoing surgical intervention, the mean time from arrival to OR was 218 minutes \pm 57 minutes (σ =353 minutes). Sources of delay of arrival to OR, included transport from referring hospitals, delay in diagnosis, operative risk, medical management for high surgical risk patients, and surgeon discretion. 55 (84.6%) patients were operative (the other 10 were not taken to the operating room secondary to patient death en route, patient refusal and chronic nature of dissection). The operative volume for type A aortic dissections and time of arrival to the operating room at our center is given in (Figure 4, 5). The in-hospital mortality for type A cases undergoing surgical repair was 16%, 12 %, and 18% in 2012, 2013, and 2014, respectively (average-15.3%). Average length-of-stay was thirteen days.

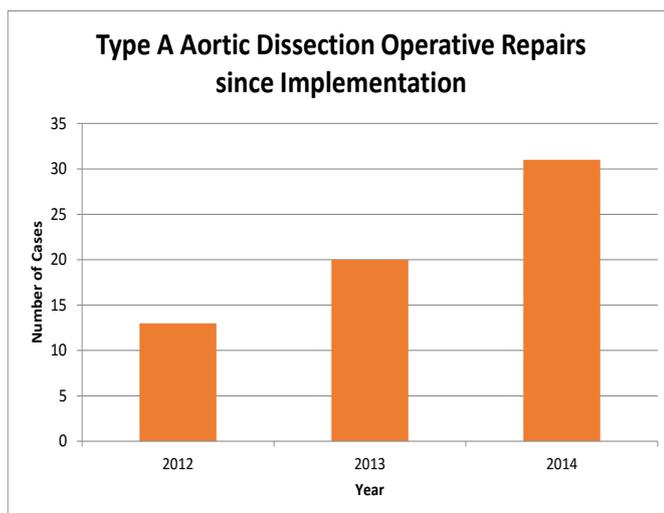


Figure 4. Annual operative type A aortic dissections at our institution. Outreach programs and advertisement for our program began in 2011 and the actual level 1 program was launched in April 2012 showing a relative growth in operative referrals.

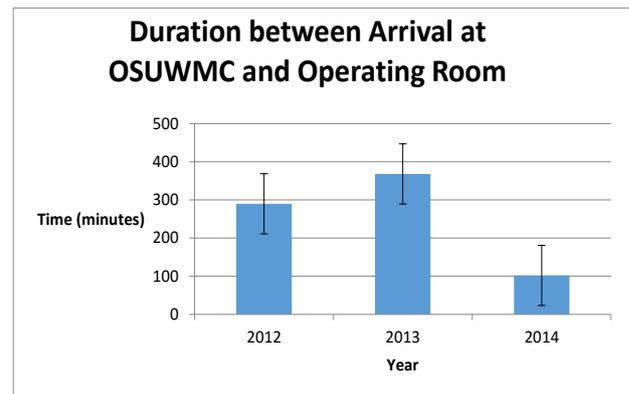


Figure 5. Time (minutes) between patient arrival at OSUWMC and Operating Room for patients with type A aortic dissections

Ruptured Aortic Aneurysm

38 patients were referred for ruptured aortic aneurysm since implementing the program. 36 (95%) patients had ruptured abdominal aortic aneurysm, and the remaining 2 (5%) were due to ruptured descending thoracic aortic aneurysm (Figure 6). Mean time from arrival at our institution to intervention was 155 \pm 51 minutes (σ =269 minutes). Of 38 patients, 28 underwent intervention (21-open repair, 7- endovascular repair), and 7 were treated medically. The remaining 3 patients expired prior to intervention or were deemed not to be candidates for surgery. Overall in-hospital mortality was 34%.

Level One: Cases by Diagnosis Apr 2012-Oct 2014

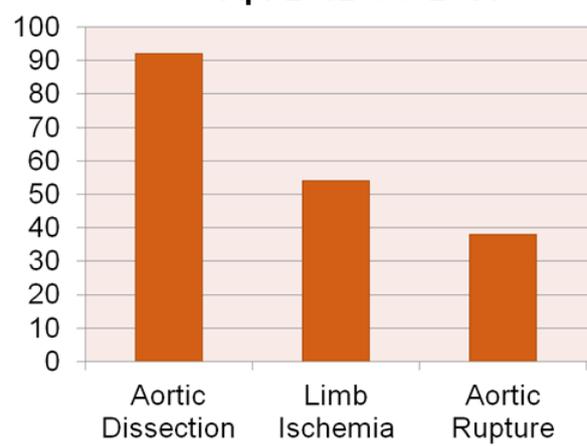


Figure 6. Case volume per cardiovascular emergency. Aortic dissection has been the most common cardiovascular emergency in our program.

Acute Limb Ischemia

54 patients underwent surgical treatment for ALI with an in-hospital mortality of 9% and average length of stay of five days. Limb salvage rate was 96% since the program's implementation. Diagnostic work up and ALI classifications

are outlined in Figure 7. 25 patients presented with Rutherford class I ischemia, 8 presented with class IIa ischemia, 15 presented with class IIb ischemia, and 6 presented with class III ischemia. Of those that presented with class IIb ischemia, where immediate intervention is typically appropriate, mean time from arrival at our institution to intervention was (325 minutes \pm 115) (σ =416 minutes). Historical controls suggest that, overall ALI incurs a 13% 30 day major amputation rate and a 20% 30 day mortality [5].

Wexner Medical Center

Acute Ischemic Limb Protocol
Level One Heart and Vascular Emergency Program

LIMB ISCHEMIA CATEGORIZATION

Class	Description	Neuromuscular Findings	Doppler
I	Viable	Pain, but no sensory or motor loss	Audible arterial and venous
IIa	Threatened (marginally)	Some sensory loss, no motor loss	Often inaudible arterial, audible venous
IIb	Threatened (immediately)	Sensory loss and some motor loss	Usually inaudible arterial, audible venous
III	Irreversible	Paralyzed and insensate	No signals

For immediate access and transfer, call 614-366-8111

Figure 7. Diagnostic work-up and Limb Ischemia categorization for our Level 1 program.

The operative volume for acute limb ischemia at our center is given in Figure 4 and our in-hospital mortality for all Acute Limb Ischemia cases is 9% since implementation.

Challenges of the Program

Barriers to implementing the program included the entire spectrum of care from ensuring correct diagnosis, activation and dissemination of awareness of the program, transportation to our facility, time to confirm diagnosis and time to definitive therapy.

In the pre-hospital setting, the biggest challenge was the activation of the emergency protocols. Often times, the referring facility and/or physician were not aware of the new program and reached the OSUWMC via traditional transfer lines. Likewise, some attending physicians at OSUWMC tended to wield the phone calls without activation of the protocol. Although the ultimate goal of getting the patient to a tertiary care center was the same, the traditional transfer routes lacked expedience of having the entire surgical, anesthesia, intensive care unit, emergency and imaging personnel readily deployed. In addition, the urgency of the transfer was lost upon the various caregivers involved in the transfer.

In the referral hospital setting, delayed or uncertain diagnosis has resulted in an inconsistent activation of emergent protocol because there were difficulties in characterizing cardiovascular diagnosis as emergent vs

non-emergent. These dilemmas lead to arrival delay, further work-up if diagnosis was not confirmed, and operative delay at the tertiary center.

In the tertiary hospital setting with the patient arrival, there was confusion regarding operative plans, need for further studies to confirm the diagnosis stemming from the large activation in the number of caretakers that were alerted with the protocol.

There are several tertiary centers in Ohio that also care for patients with cardiovascular emergencies. There are no guidelines, as compared to STEMI and trauma alerts, that establish which tertiary center would receive cardiovascular emergencies unless the referral hospital works exclusively with our program—competition remains an issue.

Conclusions

As the current health care model changes – combined with pay for performance and public outcome reporting measures, a further referral of high complexity / high morbidity cases will be seen at a tertiary care center. The potential upside of this is to further optimize outcomes and highlight the effectiveness of a regional emergency cardiovascular system. Whether this particular approach to healthcare is cost-effective remains unspecified, but regional STEMI programs which utilized regionalization strategies have proven to be cost-effective [6].

The difficulty in our program lies in actual implementation and utilization of healthcare resources: 1) activation of protocol 2) early recognition of cardiovascular emergencies at referral and tertiary centers 3) difficulties with implementing culture change at referral and tertiary centers, given this multidisciplinary approach to healthcare 4) measuring outcome metrics and 5) discouraging protocol utilization for non-cardiovascular emergencies patient.

Measuring statistical significance has been a challenge at this stage of the process because of the inadequate data (time of diagnosis to operation for each cardiovascular emergency) to notably compare pre-implementation results with the current data. It remains premature to determine statistical significance. We will continue to collect data and make comparative studies at the 6 year mark. We would measure statistical significance at the first 36 months and compare to the latter 36 month since the program's implementation.

We have constructed a committee to provide educational tools and on-site assistance for referral hospitals in order to facilitate early diagnosis and initial management of cardiovascular emergencies before patient transfer. Educational efforts to improve clinical suspicion may improve recognition of aortic dissection and rupture and encourage early management, especially in referring hospital with low volume of aortic emergencies [7]. We would continue to add and modify the interdisciplinary team, by including designated radiologists to further minimize the delay in diagnosis. Understanding the sources of delay in terms of

patient presentation and diagnostic approach (particularly in referral hospitals with limited healthcare resources), will assist physicians to determine early diagnosis, discern non-emergent from emergent, and activation of the protocol.

AAD has an associated mortality rate of 1-2% per hour immediately after symptomatic onset in patients and in recent review, 30-day surgical mortality has been nearly 15%. [8,9]. Acute aortic dissection taken care of by either high volume surgeons or high volume centers had nearly half the operative mortality and major morbidity as compared to the lower-volume centers / surgeons [10].

In future studies, we would like to include mortality percentage prior to arrival and/or surgery in our dataset for all three cardiovascular emergencies. Furthermore, we would like to distinguish time to OR between patients who were managed surgically within 12-24 hours and those who were treated thereafter. This would allow us to further understand the fragmentation of care, elucidate the source of delay in operative management, and time duration between diagnosis and operative repair. Additionally, we will expand our program to include pulmonary embolism, cardiogenic shock and cardiopulmonary collapse requiring resuscitation. We will continue to market our program to referral hospital in order to increase clinical volume.

In conclusion, the systematic approach to cardiovascular emergencies at our facility adds to the novel paradigm for treatment that has been displayed by other cardiovascular emergency systems [7]. These findings suggest that we can further optimize time to diagnosis and treatment, by addressing the barriers in executing the program's protocol.

Acknowledgement

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None

Conflict of Interest

The authors have no conflict of interest to report.

Author's Contribution

CNE – acquisition of data, drafting and revision of manuscript; AK – analysis of data, drafting and revision of manuscript; MG – design of the study, drafting and revision of manuscript; RJ – acquisition of data, drafting of manuscript; RM – concept, design, revision and editing of manuscript; AK - concept, design, revision and editing of manuscript. All authors read and approved the final manuscript.

References

1. Chikwe J, Cavallaro P, Itagaki S, Seigerman M, Diluozzo G et al. National outcomes in acute aortic dissection: Influence of surgeon and institutional volume on operative mortality. *Ann Thorac Surg.* 2013, 95(5): 1563-1569.
2. Celso B, Tepas J, Langeland-Orban B, Pracht E, Papa L et al. A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. *J Trauma.* 2006, 60(2): 371-378.
3. Glickman SW, Greiner MA, Lin L, Curtis LH, Cairns CB et al. Assessment of temporal trends in mortality with implementation of a statewide ST-segment elevation myocardial infarction (STEMI) regionalization program. *Annals of Emergency Medicine.* 2012, 59(4): 243-252.e1.
4. Graham KJ, Strauss CE, Boland LL, Mooney MR, Harris KM et al. Has the time come for a national cardiovascular emergency care system? *Circulation.* 2012, 125(16): 2035-2044.
5. Taha AG, Byrne RM, Avgerinos ED, Marone LK, Makaroun MS et al. Comparative effectiveness of endovascular versus surgical revascularization for acute lower extremity ischemia. *J Vasc Surg.* 2015, 61(1): 147-154.
6. Concannon TW, Kent DM, Normand SL, Newhouse JP, Griffith JL et al. Comparative effectiveness of ST-segment-elevation myocardial infarction regionalization strategies. *Circ Cardiovasc Qual Outcomes.* 2010, 3(5): 506-513.
7. Harris KM, Strauss CE, Duval S, Unger BT, Kroshus TJ et al. Multidisciplinary standardized care for acute aortic dissection. Design and initial outcomes of a regional care model. *Circ Cardiovasc Qual Outcomes.* 2010, 3(4): 424-430.
8. Braverman AC. Acute aortic dissection: clinician update. *Circulation.* 2010, 122(2): 184-188.
9. Kilic A, Tang R, Whitson BA, Sirak JH, Sai-Sudhakar CB et al. Outcomes in current surgical era following operative repair of acute Type A aortic dissection in elderly: a single-institutional experience. *Interact Cardiovasc Thorac Surg.* 2013, 17(1): 104-109.
10. Harris KM, Strauss CE, Eagle KA, Hirsch AT, Isselbacher EM et al. Correlates of delayed recognition and treatment of acute type A aortic dissection. The international registry of acute aortic dissection (IRAD). *Circulation.* 2011, 124(18): 1911-1918.