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The University of Western Ontario Medical Journal
Volume 81, Issue 1, Spring 2012

EMERGENCY AND CRITICAL CARE





The University of Western Ontario Medical Journal

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EDITORIAL

Editorial	5
Lauren Sham	

FEATURE ARTICLES

A primer on EMS operations for physicians and medical trainees	6
Jean-Marc Beausoleil	
<i>Faculty Reviewer: Dr. Michael Lewell, MD, FRCPC</i>	
Painless amusement: the case of a man with schizophrenia presenting to the emergency department	9
Paul A. Kudlow, Daniel James	
<i>Faculty Reviewer: Dr. Roger S. McIntyre, MD, FRCPC</i>	
Transarterial chemoembolization: the treatment, the evidence, and a patient's experience	11
Yoan K. Kagoma	
<i>Faculty Reviewer: Dr. Nirmal Kakani, MBBS, MRCS, FRCR</i>	
Contrast-enhanced echocardiography: usage, benefits and future directions	14
Brennan Ballantyne, Josh Rosenblat	
<i>Faculty Reviewer: Bryan Dias MD FRCPC</i>	
The new OACs are here... don't forget warfarin just yet!	17
Yin Hui	
<i>Faculty Reviewer: Dr. Michael J. Rieder, MD, PhD, FRCPC, FAAP, FRCP(Glasgow)</i>	

EMERGENCY MEDICINE AND CRITICAL CARE ARTICLES

The current role of focused assessment with sonography for trauma (FAST) in the ever-evolving approach to abdominal trauma	20
Brennan Ballantyne, Alden Ling and Alexander Pazonis	
<i>Faculty Reviewer: Dr. Roy W. Roebottom, MD, FCFP(EM)</i>	
Biomarkers of myocardial infarction: past, present and future	23
Joshua Rosenblat, Angela Zhang and Thomas Fear	
<i>Faculty Reviewer: Dr. Vipin Bhayana, PhD, FCACB</i>	
Application for psychiatric assessment (form 1) in the ER setting: detainment without a trial	26
Niran Argintaru and Jon Fairbairn	
<i>Faculty Reviewer: Dr. Abraham Rudnick BMedSc, MD, MPsych, PhD, CPRP, FRCPC</i>	
Medical and economic benefits of chest pain units in the diagnosis and treatment of acute coronary syndrome	29
Tommy Choy and Jessica Jackson	
<i>Faculty Reviewer: Dr. Lois Champion MD, FRCPC</i>	
Breastfeeding promotion: the NICU perspective	31
Charlotte Hunter and Stephanie Gottheil	
<i>Faculty Reviewer: Dr. Cynthia Kenyon BSc, MD, FRCPC</i>	
Interdisciplinary collaboration and relevant perspectives in critical care: suggestions to the medical student	33
Caitlin Van De Cappelle, Yin Hui and Alexander Yan	
<i>Faculty Reviewer: Anonymous Reviewer</i>	
The future of emergency medical care: novel technological approaches for improved patient management	36
Laura Callan and Melissa J. MacPherson	
<i>Faculty Reviewer: Dr. Christine Richardson, MD, CCFP(EM)</i>	



The University of Western Ontario Medical Journal

Volume 81, Issue 1, Spring 2012

www.uwomj.com

EMERGENCY MEDICINE AND CRITICAL CARE ARTICLES

An interview with Dr. Shiva Kalidindi	38
Joyce Zhang, Lauren Sham and Abdul Naeem	
Responding to an emergency – how stress affects medical trainees	39
Kim Fielding, Roman Shapiro and Elaine Tang	
<i>Faculty Reviewer: Dr. Lois Champion, MD, FRCPC</i>	
A case of an anomalous origin of left main coronary artery from right sinus of valsalva leading to sudden death	41
Yikang Lin and Stephen Cornish	
<i>Faculty Reviewer: Dr. Rod Lim MD</i>	
Larrey's revolution	43
Jason L. Chan and Justine Denomme	
<i>Faculty Reviewer: Dr. Paul Potter, MD, PhD</i>	



The University of Western Ontario Medical Journal

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COVER ART: JOYCE ZHANG

FRONT: The lights pointing to the emergency room of London Health Sciences Centre is always on, pointing patients in distress to where they can find relief and comfort in the dead of the night.

ERRATUM: The editors offer their sincere apology to Esther Chan and Niran Argintaru for incorrectly listing Niran Argintaru as a co-author of the article "Malignant airway obstruction: treating central airway obstruction in the oncologic setting" in our Airways and ENT issue, volume 80(2). We regret any inconvenience our error has caused and have corrected our mistake in the on-line version of the journal.

Editorial

Lauren Sham (Meds 2014)

They say that medical school is the time in which you learn all the “zebras” – the weird, wacky and wonderful diseases that professors briefly mention as an aside in lecture, with the hope that one day you’ll spot the illusive black and white stripes in the crowd. They also say that you never forget every time you see a zebra. This seems to ring true in this Emergency and Critical Care issue, in which two of our articles reference the same case of sudden death of a young girl, but through different lenses. One is through the eyes of our Zebra Files editors, who carefully analyzed the anatomical basis for the sudden death. The other is through the eyes of Dr. Shiva Kaldindi, a pediatric emergency physician reflecting on patients that have affected him in his practice, during an interview with our Profiles editors.

However, what’s common is common, especially in the emergency room. Our editors have taken the “common” and put their own spin onto it, revealing the story behind many issues in Emergency and Critical Care. Roman Shapiro, Kim Fielding and Elaine Tang describe the medical trainee response to stressful situations, something that our second year students may want to familiarize themselves with before heading off into clerkship. Melissa MacPherson and Laura Callan discuss novel technological advances in communication, imaging and documentation in emergency care that may come into practice by the time we become physicians. Our Clinical Procedures editors further explore one of these technologies, Focused Assessment with Sonography for Trauma (FAST) and its role in abdominal trauma. Niran Argintaru and Jonathan Fairbairn outline the clinical, ethical and legal implications of Form 1 use, which gives physicians the ability to hold a patient without consent in a hospital. Our Interdisciplinary Editors discuss the importance of inter-professional collaboration, particularly in an acute care setting. Jason Chan and Justine Denomme vividly describe how medicine was dramatically changed during the course of the French Revolution, producing the father of modern Emergency Medicine, Dominique Jean Larrey. Stephanie Gottheil and Charlotte Hunter present the importance of breastfeeding in a unique light with its own set of challenges – for babies in the NICU. Our Diagnostic Review team review the vast array of biomarkers for myocardial infarction, their pros, cons, and new techniques to come.

In this issue we have also expanded the scope of our feature articles to include a broader array of topics, instead of being confined to the issue’s theme. This has provided an increased capability to showcase students’ work and opinions in a variety of fields. In this issue, Yin Hui discusses the new oral anticoagulants that have come to market, some of which have promising features; but she cautions us to not forego Warfarin just yet. Paul Kudlow and Daniel James describe a case of a schizophrenic patient who presented with a silent acute abdomen, an atypical presentation which can lead to dangerous misdiagnoses in the emergency room. Brennan Ballantyne and Josh Rosenblat provide us with an introduction

to Contrast-Enhanced Echocardiography, pointing out applications in assessing myocardial flow, imaging the peripheral vasculature, and even ultrasound-mediated gene and drug delivery with microbubbles. Yoan Kagoma gives an account of the use of transarterial chemoembolization in hepatocellular carcinoma, in particular through the words of a patient’s experience, a unique view that we do not hear often enough. Finally, Jean-Marc Beausoleil, a former paramedic, provides us with a primer on EMS operations, with the aim of increasing our awareness of the “pre-hospital setting” which most of us are unfamiliar with.

We hope that our Emergency and Critical Care issue provides you with a look at Emergency and Critical Care beyond the setting of the everyday ER. Keep an eye out for those “zebras” – you might just encounter them.

A primer on EMS operations for physicians and medical trainees

Jean-Marc Beausoleil, Primary Care Paramedic (Meds 2015)

Faculty Reviewer: Dr. Michael Lewell, MD, FRCPC (Division of Emergency Medicine)

There are two major theatres of emergency healthcare: the hospital, with which physicians and trainees are familiar, and the pre-hospital setting. As a result, many healthcare workers know little about how the EMS system works, which can lead to confusion and delays when interactions do occur. This 'primer' attempts to increase awareness of how Emergency Medical Services (EMS) are delivered and structured in the province of Ontario.

OVERSIGHT AND DELEGATED ACTS

Paramedics in Ontario are not currently part of the Regulated Health Professions Act (RHPA), and lack their own regulatory college (this is currently being examined, [1]). The Ministry of Health and Long Term Care (MOHLTC) still holds responsibility for regulating the paramedic profession. However, providing EMS has been the responsibility of upper-tier municipalities since 2000.²

The ability to perform therapies that are considered controlled acts under the RHPA (e.g. administering a substance by injection or inhalation) are delegated to paramedics by physicians (Medical Directors) through the seven MOHLTC Regional Base Hospital Programs in Ontario (see [3] for more information on delegation.)

Together, the seven Regional Medical Directors form the Medical Advisory Committee that proposes new or revised medical directives. Final approval is dependent on provincial and EMS service management representatives, examining logistics and costs of implementation. The Medical Directives are based on the best available evidence, considering the limited diagnostic tools and resources available in an ambulance. Treatment follows the specific conditions (e.g. for cardiac ischemia), contraindications, dosing and scheduling laid out in the medical directive for administration of the indicated drugs. However, a paramedic

may use their clinical judgement to determine the patient's symptoms were from another cause (e.g. chest wall pain), and therefore that treatment is not initiated.

SCOPES OF PRACTICE

For each of the three designated scopes of paramedic practice in Ontario, there are core medical directives, which must be provided by paramedics at that level, and auxiliary directives that are approved for use but which may not be implemented by individual services.

Primary Care Paramedics (PCP)

The majority of paramedics in Ontario are PCP, requiring at least two years of college education. To be competitive for entry to most paramedic programs today, some post-secondary education is required. In addition to clinical placements in various settings, the final semester of the program is a full time field placement with a certified paramedic acting as preceptor. See Table 1 for a brief overview of PCP medical directives.

Medical Termination of Resuscitation (TOR) is a new protocol in 2011. The intention is to remove the significant risk that is associated with driving lights and siren by ceasing resuscitation when deemed medically futile. Resuscitation is initiated and, based on patient condition, the paramedics may be required to contact a Base Hospital Physician (BHP) via phone to discuss the clinical situation and request a TOR order, which is given (or not) at the BHP's discretion.

The provincial stroke bypass protocol demonstrates how rapid pre-hospital assessment by EMS can be of significant benefit to patients. Patients presenting with a probable cerebrovascular accident (CVA) should be brought directly to the nearest designated stroke centre, 'bypassing' the nearest ED. The intent is to get patients that fit the protocol crite-

TABLE 1- PCP core and auxiliary medical directives

Condition	Core skills	Auxiliary skills
Cardiac ischemia	Acetylsalicylic acid & Nitroglycerin	
Cardiogenic pulmonary edema	Nitroglycerin	Continuous Positive Airway Pressure
Chronic Obstructive Pulmonary Disease		Continuous Positive Airway Pressure
Hypoglycemia	Glucagon	Dextrose (intravenous)
Bronchoconstriction	Salbutamol & epinephrine (if severe)	
Allergic reaction (including anaphylaxis)	Epinephrine & diphenhydramine	
Pediatric croup	Epinephrine (nebulized)	
Cardiac Arrest	Semi-Automatic External Defibrillation	Supraglottic airway
Fluid administration		IV access & 0.9% normal saline
Nausea & vomiting		Dimenhydrinate
Termination of Resuscitation	Medical and traumatic cardiac arrest protocols	

TABLE 2- ACP core and auxiliary medical directives

Note: All PCP skills are included in ACP skill sets (with the exception that some auxiliary PCP skills are core ACP skills, and some shared skills have different indications)

Condition	Core skills	Auxiliary skills
Cardiac ischemia	Morphine	
Cardiogenic shock	Dopamine	
Symptomatic bradycardia	Atropine, *transcutaneous pacing & *dopamine	
Tachydysrhythmias (non-sinus)	Valsalva, *adenosine, *amiodarone/lidocaine, *synchronised cardioversion	
Seizure	Midazolam	
Opiate overdose	*Naloxone	
Hypoglycemia	Dextrose (intravenous) & glucagon	
Fluid administration	IV & pediatric intraosseous	Intraosseous (adult) & central venous access device (pre-existing)
Airway management	Naso- or orotracheal intubation	Supraglottic airway & *cricothyrotomy
Tension pneumothorax	*Needle thoracostomy	
Pain management (specific indications)	Morphine & fentanyl	
Airway obstruction	Removal with laryngoscope & Magill forceps	
Cardiac arrest	Manual Defibrillation, epinephrine, amiodarone/lidocaine	
Return of Spontaneous Circulation	Dopamine	
Combative patients		*Midazolam
Procedural sedation (intubation, pacing)		Midazolam

* Attempts to patch to a base hospital physician required before performing this skill. See [11] for more information.

ria rapidly assessed by neurologists and CT scanned so that occlusive strokes can be treated with the thrombolytic tPA (Tissue Plasminogen Activator).

Some regions have also implemented STEMI (ST (segment) Elevated Myocardial Infarction) bypass protocols, based on the fact that paramedics at most EMS services are trained to obtain and interpret 12-lead ECGs for ST segment changes. If the patient falls within the protocol criteria, the paramedics 'patch' directly to the interventional cardiologist, who can then direct the crew to bypass the ED and bring the patient directly to the catheterization lab for angioplasty. Unlike the stroke protocol, STEMI bypass is not province-wide as far fewer hospitals have the necessary resources.

Prehospital acquired 12-lead ECGs are listed as a class I recommendation in the American Heart Association guidelines, having been shown to decrease door-to-needle time.⁴ Additionally, interpretations are usually obtained before treatment has been initiated and may demonstrate findings that hospital ECGs do not, such as ST segment changes or arrhythmias that may have resolved.⁵

Advanced Care Paramedics (ACP)

PCP can later apply to an ACP certificate program, usually after writing entry examinations. Many programs also require prior work experience as a PCP (e.g. Fanshawe College requires 4000 hours within the last three years⁶). The ACP scope of practice includes all the controlled acts available to PCPs, along with a broad suite of additional delegated acts; however, not all EMS services employ ACPs. See Table 2 for a brief overview of ACP delegated acts.

Critical Care Paramedics (CCP)

ACPs with flight-medical certification can apply to the CCP program

offered by the Ornge Academy of Transport Medicine (see [7] for further information). CCP have a very broad scope of practice, including all ACP controlled acts and many that are CCP unique (e.g. chest X-ray and lab value interpretation, blood product administration, many more drugs including thrombolysis).⁸ A BHP is always on duty to provide on-line medical direction for CCPs. These paramedics are primarily employed doing critical care land and air transfers, or in the case of the helicopters, for critical calls or locations that can't feasibly be serviced by land ambulances (e.g. Pelee Island).

EMS OPERATIONS

Central Ambulance Communications Centers (CACCs)

While paramedics have authority over patient care, CACCs have authority over ambulance movements. Communications Officers at CACC act either as 911 call-takers or as ambulance dispatchers.

Dispatchers are responsible for ensuring timely EMS service and maintaining response capacity. They track all ambulances in their zone, and as units are dispatched to calls, other units are moved to cover the area of responsibility. The dispatcher must maintain constant awareness of all resources, and liaise as needed with other emergency services and hospitals. For this to be possible, ambulance movements need to be tightly linked to CACC.

The ongoing acute-care bed shortages in hospitals have had a significant impact on EMS services, as paramedic crews with low-acuity patients may end up on 'stretcher delay' for hours waiting to transfer care. This is particularly a problem in urban areas, and results in reduced emergency coverage.

The recent growth in private patient transfer companies has led to some confusion for other health care workers, who may expect an ambu-

FEATURE ARTICLE

lance to transfer patients on both inbound and return trips. Due to the demands on the system discussed above, it is rare today for non-acute transfers to be done by EMS. In any patient transfer by ambulance, acute or non-acute, the EMS crew must transfer care and return immediately to emergency coverage, their primary duty.

Allied Emergency Services

Fire personnel province-wide are responsible for rescue and extrication. Many fire services also have tiered response agreements with local EMS whereby they are dispatched to certain high-acuity calls to decrease average response time (as their base may be closer to a call) and provide manpower to the two paramedics. It is important to note that paramedics maintain overall control of care as their medical training far exceeds that of fire personnel.

Police officers and paramedics also work together regularly, although police rarely arrive specifically to assist in patient care. They are particularly important for the safety of both the patient and emergency personnel when dealing with combative patients or those with mental health issues, as they have the power to detain under the Mental Health Act or use restraints.

Air Ambulance

Air ambulances can either be requested immediately by the CACC receiving the 911 call, or by on-scene paramedics based on a series of operational and clinical criteria.⁹ The pilots first determine whether it is safe to make the flight; only then do the flight paramedics receive information about the call.

One major advantage of the air ambulance is in trauma, as it's able to rapidly transport patients from rural areas to a high-level trauma centre.¹⁰ In Ontario the air ambulance can also perform 'modified scene calls,' where a critical patient that has successfully reached the nearest ED is met at the hospital by the helicopter. The flight paramedics can then assume care from the ED staff and bypass to a trauma centre.

CONCLUSION

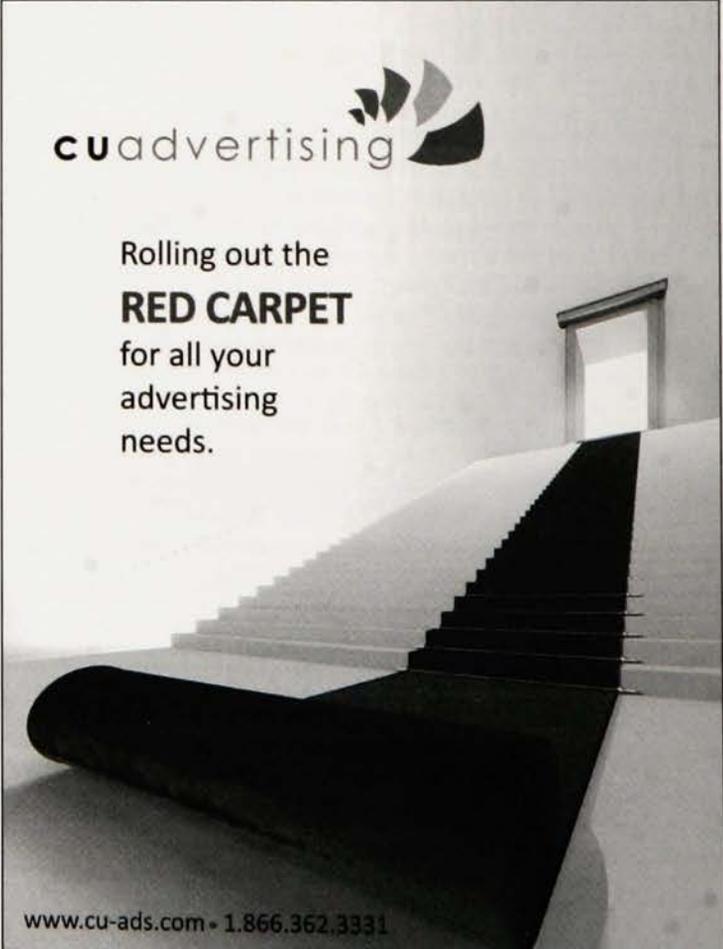
Ambulances often arrive at scenes of chaos. Paramedics, with the assistance of, CACC, medical directors, and many other factors, manage to restore some form of order and transport those requiring medical care to the waiting ED staff. Hopefully, this primer has managed to have successfully increased the reader's understanding of the unique roles of EMS and paramedics in Ontario's healthcare system, as well as some of the unique challenges that must be faced in responding effectively to medical emergencies outside of the hospital environment.

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Painless amusement: the case of a man with schizophrenia presenting to the emergency department

Paul A. Kudlow (Meds 2013), BSc. Daniel James (Meds 2013) MA, BA, BSc.

Faculty Reviewer: Dr. Roger S. McIntyre, MD, FRCPC (Department of Psychiatry, University of Toronto)

Schizophrenia, a severe mental illness affecting an estimated 0.7% of the world's population, is characterized by myriad symptoms, broadly including derangements in cognition, perception, and emotional responsiveness.¹ Along with these broad alterations, pain insensitivity, or hypoalgesia, has been reported in schizophrenia since the early 20th century.^{2,3} Despite these early and ongoing case reports, little progress has been made to elucidate the underlying mechanisms driving this peculiar symptomatology. Herein, we explore a recent case report describing a patient with schizophrenia presenting with a silent acute abdomen. Following this, we review the extant literature examining the underlying pathophysiology of hypoalgesia in schizophrenia. We conclude by proposing a novel mechanism to explain such an effect, as well as offer clinical recommendations to emergency physicians regarding appropriate management of severely mentally ill patients presenting to the emergency department.

In this recent case report, we examine Mr. T, a middle-aged man with schizophrenia, who despite a perforated gastric ulcer and an active upper gastrointestinal bleed, presented without pain, abdominal rigidity, or anorexia.⁴ Mr. T was a cachectic, disoriented male, taken to the emergency department. His vital signs were stable on arrival. Psychiatry confirmed schizophrenia and risperidone was started. The morning after admission to Psychiatry, he was tachycardic, hypotensive, hungry, but not in pain. Abdominal examination was benign, but CT found free air under both hemidiaphragms. He was taken for emergent exploratory laparotomy. The peritoneal fluid was purulent, and the stomach contained two perforated pyloric ulcers. The gastroduodenal artery was bleeding actively. Mr. T underwent corrective surgery, and was discharged from hospital in stable condition.

In this case, Mr. T experienced a silent acute abdomen. Although extremely rare in the general population, a painless acute abdomen, as well as other insensitivities to physical sensations, is not as uncommon in psychotic patients. In a study of 79 patients with psychosis, 21.4% of those with acute perforated ulcers and 36.8% of those with acute appendicitis presented without any complaint of pain.⁵ Not surprisingly, this atypical presentation often leads to dangerous misdiagnosis, resulting in higher rates of morbidity (56% in patients with schizophrenia vs. 16% in the population as a whole) and mortality (4% in patients with schizophrenia vs. 1.8% in the general population).⁶ Moreover, pain insensitivity may help to explain why individuals with schizophrenia are less likely to complain of physical symptoms related to diabetes, arthritis, infectious disease, etc.⁶ As reported in this case, instead of the classic sign of pain, patients with schizophrenia often present with worsening positive symptoms, including increasing severity of hallucinations, delusions, etc.⁷

How do we explain the hypoalgesia experienced by Mr. T and other similar patients with schizophrenia? One tactic of inquiry is to explore

mechanisms in other medical presentations where pain insensitivity is present. For example, certain stressful events, such as traumatic injuries are known to result in transient hypoalgesia secondary to increased endorphin production.⁸ It has been postulated that increased levels of endorphins may account for decreased sensitivity to pain and other symptoms of schizophrenia.⁴ However, no such correlation between hypoalgesia and levels of endogenous opioids have been found in patients with schizophrenia.⁹ Other more recent hypotheses have utilized the recent advances in our understanding of the neurobiology of schizophrenia to explain the hypoalgesic effect. Schizophrenia is known to involve dysfunction of the dopamine, glutamate, and more recently discovered cannabinoid systems.^{1,10} These neurotransmitters have also been shown to be integral to the modulation of pain perception.¹¹ Some investigators have postulated that certain neurotransmitter dysfunction seen in schizophrenia, particularly in the dopaminergic and cannabinoid systems, may underlie the deficits in pain perception.¹⁵ However, the evidence is limited by small sample sizes, generalizability, and relatively inconsistent data.¹⁵ Further research is needed to elucidate causation between the broad neurotransmitter dysfunction seen in schizophrenia and the specific hypoalgesic effect seen in this case.

Here we move away from the neurobiological explanations and offer a novel explanation that seeks to unite some of the known neuropsychological perceptual deficits in schizophrenia with the hypoalgesic effect seen in this case. We began by re-examination of the "first rank symptoms" originally proposed by psychiatrist, Kurt Schneider (1887–1967).¹² First rank symptoms, now mostly re-classified as "positive symptoms," can be broadly characterized by the feeling of being controlled by an external force. This often manifests in the patient with frank hallucinations and delusions. In 2000, Blakemore et al. published an interesting seminal work that correlated the severity of first rank symptoms with the unique ability to tickle oneself.¹³ Individuals suffering from the most severe hallucinations and delusions were found to be more likely to have an ability to tickle themselves. Based on these results, researchers proposed a feed-forward model: in normal individuals, a central efferent copy of a motor command (tickling command) is actively compared to a re-afferent signal (tickling sensation) arising from an individual's action. The signals are compared in a signal "integrator." The integrator actively compares the difference between the two signals. If none exist, the signals cancel out, and we perceive nothing (as is the case when normal individuals try to self tickle). Yet once there is a difference, the integrator generates a signal, which we perceive as a sensation. Given that patients with schizophrenia have an ability to self-tickle, yet possess intact efferent and re-afferent pathways, investigators postulated that these individuals may have a problem with the central "signal integrator" – causing it to generate erroneous signals. This forward mechanism for knowing is thought to underlie our cognitive ability to differentiate between self-produced and externally produced stimuli

FEATURE ARTICLE

- an ability thought to be impaired in schizophrenia.

This model was later validated by a recent study completed by Voss et al. Investigators found that patients with schizophrenia made global perceptual errors - often failing to associate their own actions with external events leading to persistent misinterpretation of endogenously and exogenously driven stimuli.¹⁴ Moreover, severity of positive symptoms in the patients was correlated with increasing amounts of global perceptual errors.

Intriguingly, in the case of Mr T., as well as in other similar case reports^{6,8,15}, silent acute abdomen often presents in the context of increasing severity of positive symptoms. In the past, authors postulated that the onset of an acute abdomen (overwhelmingly painful stimulus) triggers increasing positive symptoms (hallucination and delusions). Yet given the model delineated above, it is also possible, and logical to conclude an opposite temporal relationship. A high degree of positive symptoms in mental illness may lead to global perceptual errors - this in turn may be responsible for varying degrees of pain insensitivity.

Applying the model to the case, Mr. T may have a deficit in his central "signal generator," causing him to misinterpret the external pain stimulus of his acute abdomen as that of a stimulus he was creating himself. Thus, similarly to a normal individual attempting to tickle himself, Mr T simply did not feel or react. We propose that this hypoalgesia could be secondary to the global perceptual deficits typified in schizophrenia. This is in contrast to the primary mechanisms as previously described. More research however needs to be done in this area to fully elucidate how global errors in the feed forward mechanism may lead to hypoalgesia as seen in schizophrenia.

For example, a study, similar in design to the studies completed by Blakemore and Voss et al. could be undertaken to examine whether the ability to self-tickle (a validated proxy for global perceptual errors) was associated with varying degrees of pain insensitivity. If the model presented in this discussion were valid, degree of pain insensitivity would increase with higher responses to self-tickle. Extending this model one step further, since self-tickle has been postulated to be secondary to severity of positive symptoms¹⁴, patients with the highest degree of positive symptoms would be expected to have the greatest amount of pain insensitivity. Reduction of positive symptoms with administration of antipsychotics would therefore be expected to reduce degree of pain insensitivity. A study completed by Jochum et al., examined the effect of antipsychotics on the perception of pain in schizophrenia.¹⁶ Similarly to previous reports, investigators confirmed varying degrees of hypoalgesia in patients with schizophrenia. Accordingly, three days following administration of antipsychotics, pain perception differences became less apparent between patients with schizophrenia and healthy controls. The effect size was small (less than 5%). However, this was likely confounded by the short measurement window of three days. Future studies, extending the treatment measurement window, may find a larger effect size.

In conclusion, physicians must be aware of the potential atypical presentation of a patient with schizophrenia in pain. This of course has implications for triage, assessment and treatment in the emergency department. Emergency physicians should maintain a high index of suspicion for acute abdomen and other painful conditions in seriously mentally ill patients presenting with a high degree of positive symptoms or any indication of decreased pain sensation. Although a thorough head-to-toe physical exam is essential, in these patients it can be misleading. Therefore, as evidenced by the case of Mr. T, close scrutiny of any laboratory investigations or imaging studies will help to ensure that these challenging patients receive appropriate care.

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Transarterial chemoembolization: the treatment, the evidence, and a patient's experience

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ABSTRACT

Hepatocellular carcinoma is a rare, yet devastating diagnosis with limited treatment options. For selected patients, transarterial chemoembolization (TACE) is a therapeutic choice which allows for treatment that is minimally-invasive, directed, and reduces mortality. Nonetheless, it represents an innovative approach to cancer treatment and investigating its efficacy from both a biomedical and biopsychosocial perspective warrant discussion.

BACKGROUND:

In Canada, primary liver cancer (PLC) is an uncommon diagnosis with an incidence rate of 2.2 / 100 000 individuals and approximately 1950 new cases were diagnosed in Canada in 2011.¹ Current statistics from the Canadian Cancer Society indicate that the incidence rate of PLC has increased by an average of 2.9% with an associated increase in mortality over the period spanning from 1998-2007.² Major risk factors for PLC in Canada include alcohol-related cirrhosis, hepatitis C virus, and hepatitis B virus. More recently, type 2 diabetes mellitus has been linked as a risk factor for hepatocellular carcinoma.³ In developing nations, the consumption of foods containing aflatoxins and parasitic infections such as schistosomiasis and liver flukes represent additional risk factors.

Hepatocellular carcinoma (HCC) accounts for 85-90% of PLCs and once detected, treatment options are often limited. This is due to the fact that there is currently no PLC screening test and the signs and symptoms of PLC are vague, non-specific, and often do not manifest until the disease is locally advanced or has metastasized. The symptoms include: nausea, vomiting, loss of appetite, jaundice, hepatomegaly, weight loss, and fatigue. It is estimated that the median survival time for untreated HCC is less than 5 months and the 5-year relative survival rate after a diagnosis of PLC is approximately 18% in Canada.^{2,4}

After a diagnosis of HCC, the main therapeutic options are as follows:

- Resection - for localized tumour in a liver that has retained adequate synthetic function. As much as 75% of a liver may be resected in an operation. Many patients are ineligible for resection due to the size or number of liver lesions present or based on the fact that the lesions have invaded into the liver's blood supply.
- Transplant - for non-metastatic disease with an appropriately matched donor. This approach requires lifelong immunosuppression and is limited by the supply of available donor livers.
- Other - cryosurgery, radiofrequency ablation, chemotherapy, radiation therapy. This category involves many cutting-edge therapies which are still under investigation for their efficacy.

TRANSARTERIAL CHEMOEMBOLIZATION:

Transarterial chemoembolization (TACE) is a treatment for unresect-

able HCC which fits into the latter category. It is performed by an interventional radiologist and involves percutaneous image-guided access to selectively deliver a chemotherapeutic agent to the blood vessels supplying a tumour. In this way, a tumour may be specifically targeted, minimizing the systemic effects of chemotherapy (and the associated side effects) while stunting or arresting tumour growth. It is a minimally invasive approach that has been shown to improve survival for carefully selected patients with unresectable HCC.⁵⁻⁷ Patient selection is commonly based on prognostic scales such as the Child-Pugh score⁸, Model for End-Stage Liver Disease (MELD)⁹, or the Milan criteria¹⁰ which incorporate various markers of liver function, tumour characteristics, and comorbidities.

A PATIENT'S EXPERIENCE

Patient X is a 63-year-old gentleman with biopsy-proven HCC likely secondary to hepatitis C and alcoholic cirrhosis. At the time of presentation, there were no signs or symptoms of decompensated liver disease. Initial bloodwork showed a mild elevation in transaminases and elevated ferritin. Other liver studies were unremarkable.

His initial imaging studies consisted of an abdominal ultrasound and contrast CT which showed a 4.2 cm rounded mass with evidence of arterial enhancement (see Figure 1). A number of additional "suspicious lesions" were identified within the liver. Lymphadenopathy was also present in the periaortic area. These findings were suggestive of HCC.

The patient's case was then reviewed at the Liver Transplant Listing Rounds by the hepatology team and transplant teams at London Health Sciences Centre. Based on their opinions, the patient had a MELD score of 7 (low risk of mortality); however, based on location and arterial involvement, the tumours were not amenable to resection. Furthermore, based on the number of lesions and size of the dominant lesion (the Milan criteria) the patient was ineligible for transplantation. His continued intake of alcohol was also a contraindication to transplant. The decision to undergo TACE in order to control tumour growth and down-stage the tumour was made with the patient's consent.

PROCEDURE:

Initial Procedure

Access to the common iliac artery was obtained via the right common femoral artery through ultrasound guidance and the Seldinger technique. A series of angiograms were then performed which demonstrated tumour growth when compared to the initial imaging studies. In this case, the DEB-TACE chemoembolization delivery system was utilized. This consists of drug-eluting beads (DEB) loaded with doxorubicin chemotherapy. These beads are mixed with Lipiodol, a contrast agent, and then targeted at the tumour via angiography. Aside from a vasovagal incident, the patient tolerated the procedure well. A post-procedure CT

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Pre DEB-TACE #1



Figure 1: Initial CT showing large liver lesion

Post DEB-TACE #2



Figure 2: Post procedure CT showing hyperdensity consistent with DEB-TACE treatment

Pre DEB-TACE #2

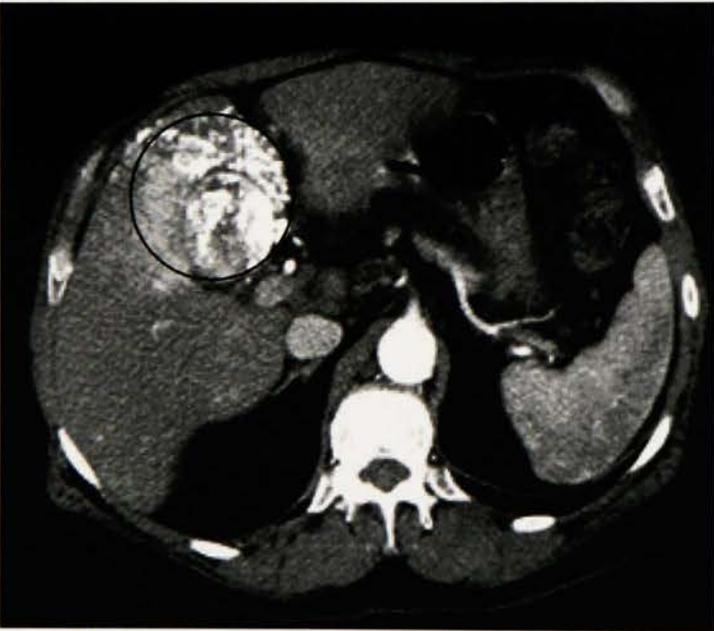


Figure 3: CT showing viable tumour in region previously treated by DEB-TACE

Pre DEB-TACE #2

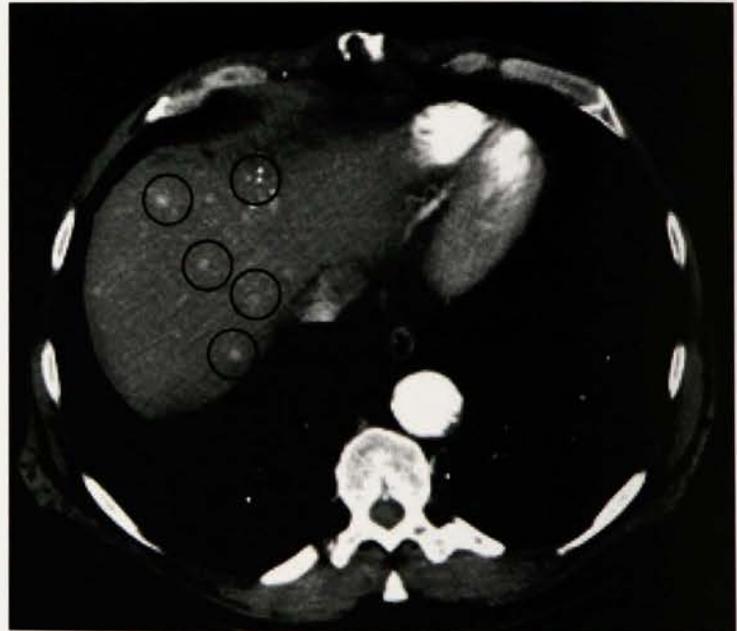


Figure 4: CT showing new areas of tumour growth

showed adequate tumour coverage (Figure 2) although residual tumour was noted and a repeat DEB-TACE procedure was planned.

Repeat Procedure

Prior to the repeat procedure, an additional CT was conducted, which showed areas of arterial enhancement suggesting viable tumour (Figure 3) as well as multiple nodules representing new tumour foci (Figure 4). The patient underwent a second DEB-TACE procedure in a similar fashion to the initial procedure. He tolerated the procedure well although a second-degree Mobitz Type 1 heart block and right bundle branch block were found incidentally which were deemed not to require treatment. Repeat CT will be conducted approximately 1 month after this last procedure to assess the tumours.

PATIENT'S EXPERIENCE:

The patient was agreeable to speaking about his condition and was interviewed with his wife prior to his second DEB-TACE procedure. Informed consent was obtained. It was a unique opportunity to gain insight into the patient's thoughts regarding his treatment experience. The conversation was guided by the National Research Corporation's 8-dimensions of Patient Centered Care.¹¹ Major highlights of the conversation were as follows:

The patient often felt that he *was not actively informed or involved in the decision making regarding his care*. He was particularly upset by the fact that little contact was made with him to discuss his diagnosis, prognosis, and treatment options. He stated that it was, "a constant feeling of not knowing what I was getting into", and his wife confirmed that

many of their questions were not addressed until her husband arrived for his first DEB-TACE procedure despite the fact that his case had been reviewed by the hepatology and transplant teams.

Approximately 5 months elapsed between the patient's ultrasound scan and his first DEB-TACE procedure. The patient and his wife could not comment directly on whether they felt this *wait was appropriate or not*. However, they were pleased with how quickly things progressed from the time they initially met with the interventional radiologist and the first procedure (approximately 3-weeks).

His experience of the actual DEB-TACE procedure was positive and the patient was *impressed by how well he tolerated the procedure*. He stated that post-op pain was minimal ("I shook it off quickly") and that he was able to work within 10 days. He had no qualms about consenting for the repeat procedure and was surprised that he had minimal post-procedure complaints. These were mainly "weakness" and "pain" which disappeared within 3-weeks.

Although not curative, the patient was *optimistic about the prospects of his treatment*. Given his lack of pre-op symptoms, it is difficult to speculate over the survival benefit conferred by the DEB-TACE treatments; however, he remains asymptomatic after completing both rounds of therapy. Follow-up CT will be scheduled for the coming months to assess the success of the latest procedure.

CONCLUSIONS:

TACE is a viable option for patients with HCC who have exhausted other treatment measures. This investigation highlights the fact that the success of a procedure should be measured by both its clinical outcomes and the patient's overall satisfaction with their treatment experience. Regardless of complexity or efficacy, every procedure is subject to the same core principles of patient care, with communication being paramount. This case highlights what can occur if these channels are severed, leading to patient dissatisfaction despite a positive clinical outcome. TACE requires the coordination of many different healthcare professionals and teams, and including the patient in all discussions should be the norm if we aim to maintain a high standard of care.

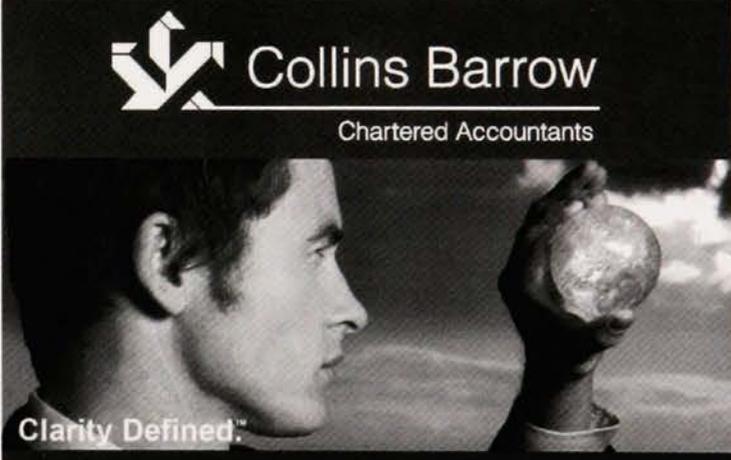
ACKNOWLEDGEMENTS:

We are greatly indebted to the patient who was agreeable to being interviewed and sharing his experiences.

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Contrast-enhanced echocardiography: usage, benefits and future directions

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INTRODUCTION

Contrast-enhanced echocardiography (CEE) is a method of echocardiography that utilizes the echogenicity of specific contrast media to greatly increase the contrast obtained between blood and tissue.¹ The concept, while over four decades old, has recently had increased attention in the clinical and preclinical realms of cardiovascular research due to advances in technology that increase its utility.

EXPLANATION OF FUNCTION

Ultrasound functions by detecting the different densities of tissues in the body based on their different responses to sound energy. CEE derives its superior resolution from the use of contrast agents carried in the circulation that respond uniquely to sound energy. It was first realized by Gramiak and Shah in 1968 that gas suspended in the blood stream alone has advantages for imaging because the density differential between gas and liquid phase provides optimal echo feedback patterns.^{2,3} However, early contrast agents were too large to navigate through the capillary network of the lungs to the systemic circulation, and would prematurely diffuse into tissues.³ Hence, newer agents were developed to be both smaller and more stable. The so called "second generation" contrast agents were composed of microbubbles of high density gas (usually fluorocarbons), encapsulated with a lipid or albumin coat. These microbubbles undergo volumetric oscillations under the pressure changes induced by the ultrasound transmitter. This vibration produces energy that can be picked up by the transducer and converted into an image.⁴ Microbubbles are very small, similar to the size of red blood cells, and are able to navigate through capillary systems without becoming lodged. They are strong enough to withstand "inertial cavitation," that is, large oscillations in energy from the ultrasound that can destroy the bubbles.⁵ Older contrast agents could only enable CEE to image the right side of the heart, limiting their role to the investigation of intracardiac or intrapulmonary shunts. The second generation agents opened a door for a new role of CEE.⁵

With advances in contrast agents, the ultrasound hardware technology had to adapt as well. Current CEE uses harmonic imaging that was developed as a way for contrast-specific imaging modalities to use lower transmission power than that used for non-contrast imaging. This is required because high transmission power causes destruction of the microbubbles and impairment of tissue signals of the myocardium.⁶ Detection methods now preferentially detect the harmonic signals given off from the microbubble oscillations, minimize the signals from tissues, and provide a very high signal-to-noise ratio.⁵

ADVANTAGES AND DISADVANTAGES

The primary advantage of CEE technology lies in its superior image quality when compared to native echocardiography, leading to more ac-

curate measurements of ventricular volumes, better detection of thrombi or hypertrophy, and improved wall motion assessment. For example, it has been found that native echocardiography consistently underestimates left ventricle (LV) volumes when compared to magnetic resonance imaging (MRI) studies because it does not have the capacity to image the trabeculation of the ventricular endocardium when measuring volume. CEE results have been found to be equivalent with MRI due to the ability of contrast agents to include the fine details of cardiac anatomy.⁶ The superior imaging capabilities of CEE are also demonstrated in patients with poor baseline quality native echocardiograms, a number that can range from 10-15% of those scanned. To our knowledge, all studies conducted have found better results after CEE in these patients.⁶

Another advantage of CEE is reproducibility of results. Native echocardiography has been criticized for high variability of measurements. This has led to a shift in patients being referred for expensive and time-consuming tests like Multi Gated Acquisition Scans (MUGA) and MRI studies. CEE has reproducibility on par with MRI, and is much less expensive.⁸ Even for technically difficult studies, such as stress echocardiography where inter-observer agreement can range from 43-100%, CEE significantly improves the confidence of the interpretation, and therefore, the reproducibility.⁹

The main limitation to CEE technology has been concerns regarding adverse events with the use of contrast agents. In 2007, the FDA issued Black Box warnings to CEE contrast agents after reports of fatalities from cardiopulmonary reactions in at least 18 patients during procedures.¹⁰ These safety concerns slowed adoption of the technology, and posed questions about the future of CEE in the echocardiography community. However, it should be noted that the risks of adverse events are very low. Comparisons of the mortality rates of various cardiac procedures shows that mortality from CEE is (1:145,000) excessively small compared to coronary angiography (1:1000) or even exercise electrocardiography (1:2500).¹⁰ The FDA currently recommends close monitoring of vitals and ECG for at least 30 minutes after administration of contrast agents.¹¹ This monitoring time may be difficult for busy echo labs at tertiary care centres, negating many of the time-saving benefits of echocardiography as an imaging modality.

INDICATIONS OF USE

As discussed above, CEE provides greater contrast between blood and tissue.¹² Therefore, organ border delineation may be determined with greater resolution and accuracy. This is often applied to endocardial border delineation, which allows for a better determination of wall thickening or other wall abnormalities.¹³ Contrast enhanced ultrasound may also be used to determine the perfusion of tissue.^{14,15} As well, it may be used to estimate the volume of blood in a given organ or section of tissue through the quantification of bubbles present and the extrapolation

tion to a representative volume of blood.¹⁶

With these concepts in mind and evaluation of the current clinical evidence of usage, the American Society of Echocardiography (ASE) published a consensus statement outlining in detail the evidence-based application of CEE.¹⁷ The ASE recommended that CEE should be considered in the following clinical scenarios:

- assessing left ventricular systolic function when quantitative volumes are required and during stress echocardiography
- evaluating the left ventricular apex
- evaluating mechanical complications of a myocardial infarction
- evaluating a potential cardiac mass
- evaluating perfusion (i.e. enhancing Doppler in the systemic circulation).

It should be noted that the above clinical scenarios are where CEE may be considered, however, CEE should not be used *routinely* in these scenarios. Rather, CEE should be used when non-CEE is not viable. More specifically, CEE should be used if two contiguous left ventricular segments are not seen on non-contrast images.¹⁷ Also of note, since the publication of the consensus statement in 2008, the efficacy of the recommendations has been evaluated and found to be highly beneficial and safe in practice.²¹ CEE may be particularly beneficial with obese patients as image quality is usually poorer with non-CEE.¹⁷

FUTURE DIRECTIONS

New Applications in Assessing Myocardial Flow

CEE is currently being used to assess myocardial perfusion, but novel applications to its use are being considered. The first is bedside CEE that could be used in emergency departments to aid in the work-up of patients presenting with chest pain. Not only could this identify higher risk patients and provide expedited treatment with the most appropriate modality, but it could obviate the need for other expensive or invasive testing.⁵ CEE could also be used in patients with recognized ST elevation myocardial infarctions to gather valuable wall motion information for prognostic purposes.¹⁸ Finally, the power of CEE for assessing perfusion has been recently used in new diagnostic situations to evaluate patients with ischemic symptoms caused by vasoregulatory mechanisms, as opposed to total obstruction of epicardial vessels. This is especially useful for gaining prognostic information in patients that suffer from diabetes, hypertension, or dilated cardiomyopathy, and guiding therapy.¹⁹

Peripheral Vascular Imaging

The ability of CEE to accurately delineate ventricular borders has been further applied to the identification of vascular borders. Recently, CEE has been used to assess vascular disease due to its ability to evaluate the vasa vasorum, the system of vessels that penetrate and supply blood to the walls of large vessels of the body. In atherosclerotic disease, expansion of the vasa vasorum has been shown to be integral in the development of plaques, macrophage accumulation and plaque rupture.²⁰ CEE may play a future role in monitoring the development of the atherosclerosis, and stratifying patients for new therapies designed to slow the later stages of the disease.⁵

Targeted Microbubbles for Specific Imaging

Many novel applications derive from the molecular targeting of microbubbles. Targeting molecules, such as ligands or monoclonal antibodies, may be conjugated to the surface of microbubbles.²² These targeting moieties may then bind to their target, localizing more microbubbles to the area of interest (where the receptor of interest is located

and enable the non-invasive ultrasonic imaging of this location. For example, inflammatory markers/receptors may be targeted to illuminate the precise location.²³ In preclinical models, microbubbles have been targeted to inflammatory regions, atherosclerosis and cancer.^{23,24,25} Furthermore, this presents the potential to use microbubbles to specifically target cells expressing certain receptors, allowing the delivery of drugs or other materials to these specific cells.²⁶

Ultrasound-Mediated Gene and Drug Delivery

Using targeted or non-targeted microbubbles, drugs or genes may be delivered to cells of interest.²⁶ Microbubbles are loaded with the drug or gene of interest and upon imaging, high frequency ultrasound is delivered to the area of interest to burst these bubbles and transiently create pores in the surrounding cells allowing for the intracellular delivery of the microbubbles' contents.²⁷ This technique is especially suited for delivery to endothelial cells as they are most easily accessible from the blood stream where microbubbles predominate. Therefore, they can be used to either destroy the endothelial cells (eg. eliminating the blood supply to cancer cells) or promote angiogenesis in the case of vascular disease (eg. promoting the growth of new blood vessels will increase the perfusion of under perfused tissue due to occlusion).^{28,29}

Centres are increasingly adopting CEE technology for the advantages it offers, especially as the safety of the procedure becomes realized. Clinical and research settings alike can benefit from the current applications of CEE, and the many more promising avenues for its use on the very near horizon.

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The new OACs are here... don't forget warfarin just yet!

Yin Hui (Meds 2015)

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Cardiac arrhythmias are health problems that become more common as people age, with atrial fibrillation (AF) being the most common cardiac arrhythmia. AF can occur due to some diseases, certain toxins, or as an adverse consequence of procedures that cause pathophysiological changes. These in turn cause the electric signal in the atria to be disturbed, which leads to rapid and irregular contractions. Irregular heartbeats disturb the smooth laminar flow of blood, leading to pooling of blood in the left atria. The conventional view is that this stasis results in thrombi formation, mainly in the left atrial appendage.¹ These thrombi can travel to the left ventricle and be ejected to systemic circulation, causing stroke when travelling to the brain, or systemic embolism when travelling elsewhere. The risk of stroke (per 100 patient years) can be predicted with a simple and validated CHADS₂ scoring system (Table 1).²

The vitamin K antagonist, Warfarin, is the most common oral anticoagulant (OAC) used to prevent stroke or systemic embolism in patients with AF. Warfarin works by inhibiting the production of clotting factors II, VII, IX, and X, and vitamin-K-dependent proteins C and S.⁴ The inhibition of these factors leads to a net effect of decreased thrombi formation, and 64% reduction in risk of stroke. However, this is accompanied by an increase in risk for bleeding.⁵ To minimize the risk of side effects while maximizing efficacy, anticoagulation therapy must be monitored, typically by measuring the International Normalized Ratio (INR) on a regular basis. The INR is an index of coagulation, with a normal value of 0.8-1.2. In most warfarin therapies, the target INR is 2.5, with an acceptable range of 2-3. Regular INR testing can be cumbersome, especially in the beginning of therapy, as patients need to have blood work done to establish an optimal dosing, at first every 2-3 days, then every week, and then every two weeks. Once an optimal maintenance dose is found, patients will continue to need INR measurements done every month for monitoring.⁶

The loading and effective doses vary widely between patients taking Warfarin. This has been attributed to a multitude of factors that affect the pharmacokinetics of the medication. Warfarin is 99.5% protein bound, and therefore displacement by another highly protein bound drug can greatly alter its bioavailability and effect. Metabolism of Warfarin depends on several different enzymes, including the cytochromes 2C9, 2C19, and 3A4.⁶ These enzymes are responsible for metabolism of many other commonly used medications, leading to drug-drug interactions. Interactions also exist with many commonly used vitamins and herbals.⁶ Common dietary foods containing vitamin K, as well as cranberry juice and green tea, often will also affect the efficacy and safety of warfarin.⁷ Genetic polymorphisms of the vitamin K receptor VKORC1 and the cytochrome CYP2C9 make predicting the effective dose and establishing maintenance dose even more difficult.⁶ Routine genotyping to establish dosing has been shown not to be cost effective, although the cost as-

sumptions that this was based on may be dated.⁸ Finally, Warfarin has a half-life of approximately 40 hours, leading to effects of changes in dosing to be expressed several days later. Coupled with variability in a person's everyday life, it can be difficult to determine the causes of changes in INR. Difficulty in managing warfarin therapies have led to patients being within the therapeutic INR range only ~50% of the time.⁹

In an attempt to overcome the challenges with Warfarin, both anti-coagulant and antiplatelet agents have been evaluated. In 2003, ximelagatran (Exanta™, AstraZeneca), a direct thrombin inhibitor, has been approved in some European countries for use in prevention of stroke and systemic embolism for patients with AF, as well as for venous thromboembolism (VTE) after orthopaedic surgery. It was the first OAC marketed as a replacement for warfarin.¹⁰ However, due to severe liver toxicity discovered post-market, ximelagatran was withdrawn worldwide in February 2006.¹¹ In the ACTIVE-W trial, warfarin was compared to combination therapy with acetylsalicylic acid (Aspirin™, Bayer) and clopidogrel (Plavix™, Bristol-Myers Squibb and Sanofi-Aventis), with Warfarin proved to be superior in efficacy and safety.¹² In the AMADEUS trial, Warfarin was compared to idraparinux (Sanofi-Aventis), a subcutaneous factor Xa inhibitor similar to fondaparinux, with idraparinux having significantly more bleeding events.¹³

More recently, several new OACs have been developed and brought to market. Dabigatran (Pradax™, Boehringer Ingelheim), a direct thrombin inhibitor, rivaroxaban (Xarelto™, Bayer), a factor Xa inhibitor, and apixaban (Eliquis™, Pfizer and Bristol-Myers Squibb), also a factor Xa inhibitor, has already been shown to be effective in prevention of VTE after orthopaedic surgery, joining the ranks of unfractionated heparins and low molecular weight heparins.¹⁴ In 2009, the Randomized Evaluation of Long-Term Anticoagulation Therapy (RE-LY) trial demonstrated dabigatran to be superior to Warfarin in prevention of stroke and systemic embolism due to AF on the recommended dose of 150mg twice daily, and non-inferior when using 110mg twice daily for elderly patients or patients with reduced renal function.¹⁵ Subsequently, the Rivaroxaban Once Daily Oral Direct Factor Xa Inhibition Compared with Vitamin K Antagonism for Prevention of Stroke and Embolism Trial in Atrial Fibrillation (ROCKET-AF) trial showed rivaroxaban to be non-inferior to Warfarin in managing high-risk patients at 20mg daily.¹⁶ Most recently, the completion of Apixaban for Reduction in Stroke and Other Thromboembolic Events in Atrial Fibrillation (ARISTOTLE) trial showed that apixaban was non-inferior to Warfarin at 5mg twice daily.¹⁷ While each trial has weaknesses, there is a general trend of improved efficacy and safety in their use.

These new OACs boast long awaited qualities: few drug interactions, virtually no dietary interactions, efficacy and safety not affected by genetic polymorphisms, quick onset, short half-lives ensuring quick offset, no need for laboratory monitoring, and improved safety profiles.

FEATURE ARTICLE

Specifically, hemorrhagic stroke and serious bleeding had statistically significant risk reductions for all three agents.¹⁵⁻¹⁸

However, there are also proposed disadvantages associated with these agents both individually and as a group. Dabigatran caused potentially severe heartburn or reflux in 11% of patients in RE-LY.¹⁵ ROCKET-AF had several major weaknesses in the trial design, leading to uncertainties about the true efficacy and treatment effect of rivaroxaban. Guidelines have yet to be developed for apixaban in regards to switching to and from warfarin, or holding for surgery at the time this article is written.

As a group, there are numerous down sides to the new OACs as well. To begin with, Warfarin has been used for the past 50-60 years gathering a large body of evidence and experience, whereas the new OACs come with very few studies and little clinical experience. For example, there is reasonably robust evidence for Warfarin use in vulnerable populations such as pediatrics, whereas this population is routinely excluded in all of the trials involving the new OACs.¹⁹⁻²¹ In addition, many comorbidities were excluded by RE-LY, ROCKET-AF, and ARISTOLE, such as valvular AF, creatinine clearance <30 ml/min, and active liver disease. Given that the potential for significant adverse events in these excluded populations cannot always be extrapolated from existing data, caution should be taken in introducing new OACs to these patients.

Second, the new OACs have no reliable measurement of effect. The sign of inefficacy is simply the occurrence or recurrence of stroke or systemic embolism. On the other hand, Warfarin's regular need for INR monitoring can be beneficial. INR provides a surrogate marker of the efficacy of therapy. This allows Warfarin to be used in conditions excluded by RE-LY, ROCKET-AF, and ARISTOTLE, because there is a monitoring system available to adjust dose based on the INR.

Third, as Warfarin has been used for more than 50 years, its long-term efficacy and safety have been studied and well known. On the other hand, the "oldest" new OAC, dabigatran, just came onto market in 2010. Rivaroxaban and apixaban just concluded their landmark trials within the past year. A long-term study of dabigatran, the RELY-ABLE trial (NCT00808067), will evaluate its long-term efficacy and safety for a maximum of just 28 months after first use.²²

Fourth, none of the new agents has corresponding antidotes that have been shown to predictably and reliably reverse their effects. In comparison, Warfarin has a reliable reversal agent in situations of overdose/toxicity – vitamin K, with established reversal guidelines.⁶ For the new OACs, clinicians can use dialysis, flash frozen plasma, prothrombin complex concentrates (PCC), or recombinant activated factor VII (rFVII) in situations of bleeding, although the efficacy of any of these approaches have not been demonstrated.²³ Experts have developed a set of recommendations for treatment of anticoagulant associated bleeding for the new OACs. However, these recommendations are often based on

anecdotes and their efficacy remains theoretical.²⁴ The lack of reliable reversal agents, combined with the lack of evidence for use in patients with poor renal function, leads to uncertainty of use in frail, elderly patients, especially those of poor health.²⁵

Fifth, the short half-life of these new agents make them not fitted for patients who are non-compliant (due to forgetfulness or otherwise). These agents have half-lives less than 12 hours and reversible inhibitory effects.¹⁵⁻¹⁷ Missing one dose could significantly affect circulating drug levels and clotting factor inhibition, leading to changes in efficacy. However, no studies have been done to investigate this effect.

Finally, the new OACs cost up to \$300/month, which is significantly more expensive than Warfarin therapy and INR monitoring combined.²⁶ The Ontario Drug Benefit plan has yet to add these medications to its formulary for AF. Therefore, patients would have to pay out-of-pocket, or use a third party payer, if therapy is desired. High cost of the medications may also pose a barrier in incorporation into the hospital formularies, since the cost would significantly affect the pharmacy budget.

In light of current information, the new oral anticoagulants are an excellent alternative to Warfarin in certain situations. They offer highly desired benefits of convenience and safety. In a non-valvular AF adult patient who is often compliant, with no active liver disease or severe renal dysfunction, the new oral anticoagulants can offer a much better medication experience. So far, only dabigatran is approved on the Canadian market for use in prevention of stroke and systemic embolism in patients with AF. Several major teaching hospitals are looking at, or have added dabigatran into their formulary.²⁷

As head-to-head trials between the new OACs will not be beneficial for the parties involved, it is unlikely these trials will be conducted in the near future. Therefore, when given a choice, clinicians should use their clinical judgement to choose the agent, taking into account individual patient conditions, as well as known safety and efficacy data of each drug. As these new OACs are used and studied more often, clinical experience and evidence may provide new facets of their use. With the rapidly changing landscape, anticoagulation is certainly an area worth watching. For now, don't forget about Warfarin just yet!

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Criteria (one point each)	CHADS ₂ Score	Stroke Risk	Recommended Therapy
C Congestive Heart Failure	0	1.9 %	ASA
H Hypertension	1	2.8 %	OAC or ASA
A Age >75 years	2	4.0 %	OAC
D Diabetes Mellitus	3	5.9 %	OAC
S Prior stroke or TIA (2 points)	4	8.5 %	OAC
	5	12.5 %	OAC
	6	18.2 %	OAC

ASA = Acetylsalicylic acid; OAC = Oral anticoagulant

Table 1: Patient's risk of stroke (per 100 patient years) as determined by the CHADS₂ score. Adapted from the Stroke Prevention in Atrial Fibrillation (SPAF): Pocket Reference.³

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The current role of focused assessment with sonography for trauma (FAST) in the ever-evolving approach to abdominal trauma

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Faculty Reviewer: Dr. Roy W. Roebtham MD FCFP(EM) (Division of Emergency Medicine)

BACKGROUND

Trauma is the leading cause of mortality worldwide, and is a leading cause of death in both men and women under the age of 35.^{1,2} Apart from the high incidence of mortality, trauma is responsible for leaving 45 million people per year worldwide with moderate to severe disabilities.¹ It is no surprise that victims of traumatic events have significantly better morbidity and mortality outcomes when treated at centres with designated trauma units, where there are health care professionals that have been trained in specific triage, diagnostic and treatment techniques to manage trauma patients.³

One of the main complications leading to high mortality after trauma is exsanguination from injuries to organs of the abdomen. The liver and spleen are the most common culprits, with the kidneys injured often as well.⁴ Blunt abdominal trauma is most frequently caused by motor vehicle accidents involving both vehicles and pedestrians. A minority of other causes include blows or falls involving the abdomen.⁵ The evaluation of abdominal trauma is one of the most challenging areas of acute trauma management because injuries may not manifest in the initial assessment, physical findings are often unreliable, the presence of other injuries causes difficulties, and the patients can present with altered mental status from head injuries or intoxication.⁶ Historically, blunt abdominal trauma was even more difficult to manage because practitioners lacked the non-invasive and expedient imaging techniques that are available today. Non-therapeutic laparotomy was the primary method by which trauma personnel uncovered significant abdominal injury. However, laparotomy carries a risk of complication (0.8-2.3%) and exposes the patient to the short- and long-term sequelae of the procedure.⁷ There has been a continuous search for accurate and expedient tests that can detect occult bleeding and obviate the need for invasive procedures, such as the non-therapeutic laparotomy.

DIAGNOSTIC PERITONEAL LAVAGE

The first report of the diagnostic peritoneal lavage (DPL) was in 1965, and represented a major advance in the assessment of abdominal injury. The study was small, but it was able to diagnose hemoperitoneum in 100% of patients that presented with blunt abdominal trauma.⁸ Since this initial investigation, many studies have supported the results, and there has been a gradual increase in the use of DPL at trauma centres as a replacement for the non-therapeutic laparotomy. One such study by Danne et. al. in 1988 found that only 0.25% of patients were not correctly diagnosed within 4 hours of arrival to the trauma centre, and false negative and positive rates were similarly very low. Few complications of the procedure were reported.⁹

The primary function of DPL is to detect occult injuries in hemodynamically unstable patients that have sustained either blunt or penetrating abdominal trauma, even with a low threshold of suspicion. A second-

ary function also developed, namely, to save unnecessary laparotomies.¹⁰ The principle of DPL is to infuse fluid into the peritoneum to mix with possible intraperitoneal blood, and to recover the fluid through drainage. A small, midline incision is made in the sub-inguinal region, and the linea alba is separated. A peritoneal dialysis catheter is inserted into the peritoneum and held in place by a purse string suture. Warm saline solution (0.9%) is then infused, drained, and sent for analysis. Depending on the experience of the physician, the entire procedure can take between 5 to 30 minutes. However, there are some significant limitations to the DPL.⁹ The procedure is invasive, it provides no information regarding the organ that is injured, it has a high rate of negative laparotomies, and it can be time consuming if the operator is unskilled. Therefore, newer ultrasound-guided techniques have largely eclipsed the DPL.

FOCUSED ASSESSMENT WITH SONOGRAPHY FOR TRAUMA

An ultrasound-based assessment for trauma patients became popular in the early 1990s, addressing the shortcomings of DPL. The technique called Focused Assessment with Sonography for Trauma (FAST) was found very early to be accurate, non-invasive, and could provide expedient aid in the decision-making process for further treatment in the critical care setting. FAST is a bedside ultrasound assessment protocol that can be performed rapidly as a screening tool for the detection of intraperitoneal injury and, less commonly, pericardial tamponade.¹¹ The assessment is not overly complex, and can be performed by surgeons and radiologists with equal reliability.¹² Currently, FAST is most often used by surgeons and physicians in the emergency department. Canadian ER practitioners call the technique Emergency Department Targeted Ultrasound (EDTU).¹³

FAST is performed with the patient supine (if possible) and uses a mobile ultrasound machine. The depth of ultrasound wave penetration must be at least 20cm, so the transducer frequency that is usually required is 3.5-5MHz with a convex transducer. Several views are obtained of high risk areas of the abdomen prone to fluid accumulation after abdominal trauma. A longitudinal view of the right upper quadrant will allow visualization of the hepatorenal recess (Morison's pouch) that can show free fluid after a liver laceration. A longitudinal view of the left upper quadrant to visualize the perisplenic space will assess for splenic and renal injuries. Both transverse and longitudinal views of the suprapubic region (pouch of Douglas) are used to rule out urinary bladder rupture. Finally, a transverse view of the subxiphoid region is sometimes obtained to assess for free fluid of the pericardium.¹¹ When performed by experienced sonographers, the entire exam will take no longer than 5 minutes to complete. However, complications in obtaining the standard views can prolong the assessment.¹¹

FAST is currently indicated to be used in the primary circulatory

survey of an unstable patient that has sustained blunt abdominal trauma for detection of intraperitoneal and pericardial fluid. A secondary indication of FAST is the assessment of the thoracic cavity to detect a possible pneumothorax. This protocol, termed extended FAST (E-FAST; or EDTU-2 in the Canadian ER), is performed on unstable trauma patients if there is time after the primary survey. This exam is based on the principle that air in the pleural cavity can be distinguished from air in the lungs with ultrasound during normal ventilation. E-FAST has reported sensitivities and specificities of 0.59-1.00 and 0.94-1.00, respectively.¹¹ It is currently unclear whether an E-FAST should be routinely conducted in the critical care setting, but it is reasonable to conclude that if there is sufficient time, an E-FAST can be performed to rule out pneumothoraces before patients go to the CT suite or surgery.

ADVANTAGES AND LIMITATIONS OF FAST

The FAST protocol has many key advantages that make it superior to DPL in the assessment of abdominal trauma. FAST boasts relative ease of use, rapidity, availability, and low cost imaging. It offers greater flexibility for patient positioning, which is very important for patients who have undergone significant trauma. It can be employed within minutes of a patient's arrival at a critical care centre, while other health care personnel perform diagnostic and therapeutic maneuvers simultaneously.¹⁴ A 2007 study found that patients with positive FAST results had significantly higher mortality than FAST-negative patients. FAST-positive patients also had a higher likelihood of operation than FAST-negative patients. Patients with equivocal FAST results, or areas that could not be well visualized, were found to have more statistically significant negative results and had a higher likelihood of operation than FAST-negative patients.¹⁴ However, equivocal results only made up 6.7% of the assessments when FAST was undertaken by trained clinical sonographers.¹⁵ These results highlight the importance of FAST as an effective method for identifying patients at risk of serious intraabdominal injury. FAST results can be used to guide mobilization of hospital resources, and identify patients who can be managed expectantly.¹⁴

However, limitations to the FAST technique do exist. Firstly, FAST does not accurately detect the extent of, in some cases, the precise site of organ injury. Therefore, FAST-positive patients often need to be fol-

lowed up with a CT scan to locate the origin of the bleeding and evaluate the extent of the injury.¹⁶ The sensitivity of FAST is also low (34-55%) relative to other imaging modalities available.¹⁷ Other limitations of FAST are aspects that are inherent to ultrasound itself as an imaging modality, such as operator dependence, inability to completely standardize the procedure, limited retroperitoneal accuracy, and poor scanning results in obese patients or patients with tissue abnormalities like superficial wounds.¹¹

DEBATE ABOUT THE CURRENT ROLE OF FAST

There is considerable debate about what should be done in the case of negative FAST results for hemoperitoneum. Some studies show as many as 29% of negative scans still have some degree of intraabdominal injury.¹⁸ Since CT scanning has become more widely available, faster, and a more economical test than it was in the past, it has come to dominate much of the survey of abdominal trauma patients. CT is a more accurate test than FAST, especially when comparing the false negative rates of both tests. The discordance in the results of CT and FAST have led to some centres adopting the CT scan as the primary imaging modality for blunt abdominal trauma.¹⁸ However, the utility of FAST is only questionable when it is used as a purely diagnostic tool. Recent evidence suggests that clinical suspicion should still play an important role in determining the therapeutic steps for trauma patients. For example, if a patient sustained a seatbelt injury, a negative FAST result could probably still be followed with a CT scan to ensure that no intraabdominal injury exists.^{19,20} A stand-alone FAST result should not preclude patients from further investigation, or guide treatment by itself. It is in this setting that the value of FAST is realized. As a screening tool implemented in the primary circulatory survey, along with available clinical evidence, FAST is instrumental in the first decision point for trauma patients: to the OR or further investigation?¹⁴ Figure 1 depicts a typical decision tree, where FAST is integral to the early steps. In this role, FAST-positive patients can be dealt with in the most expedited manner possible, and patients with negative or equivocal results can undergo further testing. This approach still results in effectively identifying the maximum number of at-risk patients, while using CT scanning sparingly. This saves the hospital money, frees up valuable CT suite time, and avoids unnecessary radiation exposure to patients. Overall, FAST can be viewed not as a

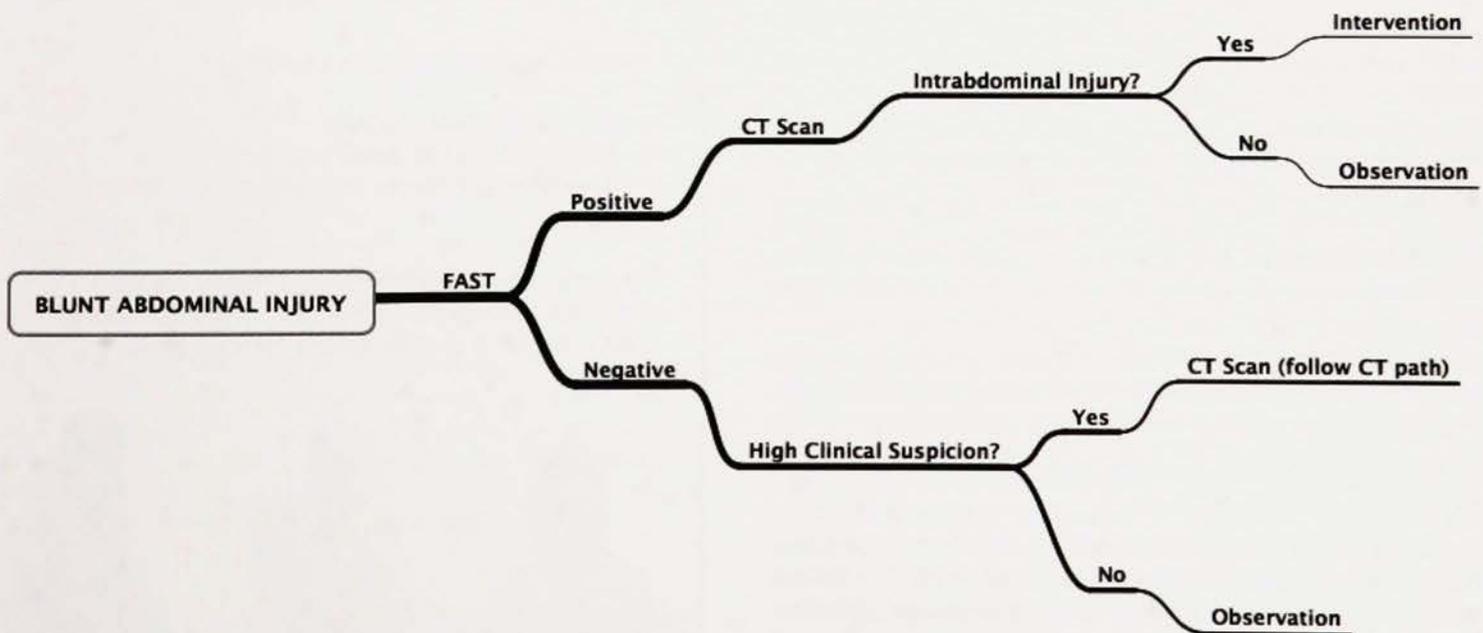


Figure 1. The typical decision-making process involved in the assessment of blunt abdominal injury. Adapted from van der Viles et. al.²¹

CLINICAL PROCEDURES

solitary solution to a diagnostic problem, but as an adjunct to the triage and decision-making process. In this capacity, there will still be a very integral role for FAST in the work-up of blunt abdominal trauma patients for the foreseeable future.

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Biomarkers of myocardial infarction: past, present and future

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INTRODUCTION

For the past 40 years, the use of biomarkers has been extremely valuable in the early diagnosis of acute myocardial infarctions (AMI). Sensitivity, specificity and the clinical utility have continued to increase and current research suggests that this trend will continue. This article will review the use of previous and current AMI markers and will conclude with a review of promising new markers.

AMI BIOMARKER PROTOCOL

To detect MI markers, venous blood is routinely drawn from patients with chest pain who are suspected of having symptoms of acute coronary syndrome (ACS).¹ The marker of interest is presumed to be released from the cardiac tissue which is under ischemic stress and thus may be detected in the blood sample.² A detected elevation in a particular marker may lead to early diagnosis and treatment and thus improved patient outcomes.¹

Characteristics of biomarkers centre around three main elements, namely, kinetics of release, specificity and sensitivity.³ An ideal marker of cardiac necrosis should exhibit the following characteristics: cardiac specificity, early and stable release after necrosis, predictable clearance, and be measurable quantitatively using rapid, cost effective methodologies available in the majority of clinical laboratories.⁴

PAST AND PRESENT AMI BIOMARKERS

Myoglobin

Myoglobin is a heme protein found in almost all muscle types and is especially high in cardiac and skeletal muscle.⁵ Quantitative immunoassays are currently available. This marker's strength is its high and early sensitivity post-MI. The marker's obvious weakness is the low specificity due to the presence of high levels of myoglobin in skeletal muscle.⁵ Therefore, myoglobin is suggested not to be used on its own but only in the context of other markers, EKGs and clinical evaluation.

Lactate Dehydrogenase

Lactate Dehydrogenase (LD) is an enzyme involved in anaerobic metabolism, reversibly converting pyruvate to lactate.⁶ LD is fairly ubiquitous; however, one of the five isoenzymes, LD1, is highest in cardiac tissue. LD1 is elevated post-MI and the LD1:LD2 ratio when greater than 1.0 is diagnostic of an AMI. LD1 elevation and LD1:LD2 ratio changes are detectable 8-12 hours post MI and peak at 24-72 hours.⁷

Creatine Kinase

Creatine Kinase (CK) is an enzyme found in high amounts in muscle tissue due to its role in muscle contraction.⁸ CK has two subunits, M and B, which are combined to form three isoenzymes: CK-BB (CK-1), CK-MB (CK-2) and CK-MM (CK-3).⁸ CK-MB is specific to cardiac

tissue while CK-BB is found in brain tissue and CK-MM is in skeletal and cardiac tissue.⁸ Furthermore, release of CK-MB only occurs upon death of myocardial cells and it is not released in the setting of ischemia.⁹ Therefore, CK-MB was considered to be the most useful biomarker for detecting myocardial injury. Kinetic studies have shown that CK-MB is detectable 4-8 hours after the first onset of chest pain and peaks at 18-24 hours post MI.^{8,9} However, the CK-MB Immunoassay lacks absolute specificity, is absent in minor myocardial infarctions, and has poor prognostic value in ACS patients. Despite these weaknesses it is currently a routine part of the cardiac work-up.

In the 1970s and 1980s, CK-MB transformed the diagnosis and treatment of patients with acute cardiac events. CK-MB proved even more specific than an accurate clinical history, which is often unattainable in the critically ill or is atypical in the elderly and diabetics. CK-MB was more reliable than EKG pattern recognition which can be blind to disease depending on the location of the ischemia. CK-MB also improved specificity over myoglobin (90% vs 70% specificity, respectively) and consequently became the gold standard for identification of cardiac injury. In the absence of myocardial infarction, CK-MB may be elevated due to poor specificity in patients who present with multiple co-morbidities or conditions including renal failure, non-cardiac surgery, chest trauma, asthma, pulmonary embolism, chronic and acute muscle disease, head trauma, hyperventilation, and hypothyroidism.^{10,11}

Troponin

While troponin proteins are present in both cardiac and skeletal muscle, the cardiac isoforms of troponin T and I are highly specific to the myocardium. Assays using specific antibodies against cardiac troponin T or I allow measurement of troponin release from the myocardium.⁴ In 2000, the European Society of Cardiology (ESC) and American College of Cardiology (ACC) task force concluded that diagnosis of AMI required biochemical evidence of necrosis and indicated the marker of choice as troponin.¹²

The increased sensitivity of cardiac troponin over CK-MB is primarily due to the fact that the percentage of troponin released into the blood after an acute cardiac event is greater for troponin than CK-MB. Troponin concentrations rise quickly after the onset of chest discomfort. Thus, in upwards of 80% of patients, a definitive diagnosis can be made within 6 hours from the onset of chest pain. Furthermore, peak concentration of CK and troponin give a reasonable estimate of infarct size. More recently, novel prototype cardiac troponin assays have been developed that are up to 10-fold more sensitive than the currently used assay and yield prognostic value on potential future MIs.^{13,14} For comparison of troponin and other available markers please see Table 1.

Troponin has become the biochemical marker of choice for the detection of cardiac injury. But still lacks sensitivity within the first hour

DIAGNOSTIC REVIEW

Table 1: Summary of AMI biomarkers

Marker	Isoenzyme/Isoform	Reference range	First Detectable (post MI)	Peak of Release (post MI)	Sensitivity/ Specificity
Creatine Kinase	CK-MB	<6U/L	4-8h	18-24h	90%/80%
Lactate Dehydrogenase	LD1/LD2 ratio	<1.0	8-12h	24-72h	90%/90-99%
Myoglobin	N/A	15-120 ug/L	2-4h	10-12h	99%/70%
Troponin	cTnI, cTnT	<0.08 ug/L	2-8h	18-24h	99%/99%

of an AMI.¹⁵ Furthermore, clinical guidelines still dictate that Troponin results should be interpreted with clinical findings and EKG results and not in isolation.¹⁶

FUTURE MARKERS

While current markers have greatly improved the diagnosis and quickened the treatment of AMI patients, there is still room for improvement, especially in the area of early detection.³ The following markers are some of the potential MI markers of tomorrow that may improve sensitivity, specificity, prognostication and decrease time between (or even predict) chest pain onset and diagnosis/treatment.

Myeloperoxidase

Myeloperoxidase (MPO) is a haemoprotein produced by polymorphonuclear neutrophils (PMN) and macrophages. It converts chloride and hydrogen peroxide to hypochlorite which is released during inflammation and is involved in lipid oxidation that is contained in LDL particles. This process promotes formation of foam cell in atherosclerosis. MPO is a marker of plaque instability and therefore presents as a potential strong prognostic marker of an MI in the near future. MPO is lowest in patients with stable coronary artery disease, higher in patients with unstable angina, and highest in patients with AMI.¹⁷

Copeptin

Copeptin is the C-terminal fragment of the vasopressin precursor hormone which is released in response to low blood pressure. Also, the measurement of copeptin has been shown to have very strong negative predictive value, along with troponin, for AMI.¹⁸ Additionally, copeptin levels are elevated early after AMI and are detectable in patients who present soon after symptom onset while troponin is still negative.¹⁹

Growth differentiation factor 15

Growth differentiation factor 15 (GDF-15) is a transforming growth factor. Cardiomyocytes express and secrete GDF-15 in the setting of ischemia and reperfusion, suggesting that it might be a protective factor. As well, GDF-15 has been identified in activated macrophages, and a distinct up-regulation has been found in many tissues following injury, ischemia, and other forms of stress.²⁰

Heart-type fatty acid-binding protein (H-FABP)

H-FABP main advantage is that it is released soon after cardiac injury and thus may be a great potential improvement from myoglobin as an early biomarker. The main disadvantage is that it is not exclusive to heart (also is found in skeletal muscle – although in much smaller amounts).²¹ Additionally, it is useful in distinguishing risk even in patients without elevated BNP or Troponin.²²

B-type natriuretic peptide (BNP) and N-Terminal fragment of pro-BNP (NT-proBNP)

BNP is a neurohormone released from cardiac cells following vertical wall stress and myocyte stretching.²² Both the active form BNP, and the inactivated N-Terminal peptide “NT-proBNP” can be mea-

sured as markers of hemodynamic stress). While investigations have shown that elevated BNP and NTproBNP levels are predictive of death and heart failure, they are not useful as indicators of new or recurrent AMI.^{23,24} More research is being conducted to establish the use of these biomarkers for selecting treatment of acute coronary syndromes.²²

high sensitivity C-reactive protein (hsCRP)

C-reactive protein is a marker of inflammation and may be part of the mechanism of atherosclerotic plaque producing thrombus. Elevated levels are predictive of death and heart failure post MI. hsCRP is non-specific for cardiac inflammation; however, measurements of forms specific to vascular inflammation are being developed and may be more specific for AMI.²⁵

placental growth factor (PIGF)

PIGF is also a useful indicator of plaque instability – more specifically – may be a determinant/cause of plaque instability and thus is a potential drug target to prevent AMI.²⁶

WBCHO and plasma choline (PLCHO)

Whole blood choline (WBCHO) includes measurement of choline in hemolysed erythrocytes. Choline leaks from ischemic tissues into plasma. In plasma, it is eventually taken up by blood cells (hence the differentiation between these two measurements). Both whole blood choline and plasma choline levels are of use for predicting cardiac ischemia in patients with negative troponin. The use of whole blood choline may also extend to determining plaque stability. Thus, these markers might be of use for predicting myocardial infarct (detection pre-necrosis).²⁷

CONCLUSIONS

Over the past several decades, the use of cardiac biomarkers has greatly improved the diagnosis of AMIs. As more markers have emerged, sensitivity and specificity has increased and time to diagnosis and treatment has decreased. Currently, the best marker available in clinical practice is troponin; however, even troponin results should be interpreted within a clinical context and not used in isolation. Furthermore, there is still room for improvement and current research seems to suggest there are more markers still to come which will improve AMI diagnostics, prognostics and prediction.

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Application for psychiatric assessment (form 1) in the ER setting: detainment without a trial

Niran Argintaru (Meds 2014) and Jon Fairbairn (Meds 2014)

Faculty reviewer: Dr. Abraham Rudnick BMedSc, MD, MPsych, PhD, CPRP, FRCPC (Departments of Psychiatry and Philosophy)

J, a 36 year old mother of two, is brought into the emergency department by police following her neighbours' complaints of violent threats made by her towards them. J has a history of manic depressive episodes but has never acted violently or displayed homicidal ideation. The attending emergency physician examines J and notes that she has recently demonstrated recurrent episodes of unexplained aggression towards family members. The physician is concerned that this presentation represents a worsening of J's psychiatric illness, and that she could present a risk to herself, her family or her neighbours.

The application for psychiatric assessment (APA), also known as a Form 1 in Ontario, is a widely used tool available to physicians who have a "reasonable cause" to believe a person should be mandated to undergo a psychiatric evaluation in an in-patient setting. Here we review the circumstances under which a Form 1 can be applied, highlighting the legal basis and focusing on its use in the emergency department. We also outline the patient's rights when a Form 1 is applied to them, as well as the consequences for the patient and the responsibility of the signing physician as outlined under sections 15, 18 and 20 of the Ontario Mental Health Act.¹ In addition, we will discuss some of the ethical and legal implications of Form 1 use.

THE LEGAL BASIS OF FORM 1 USE

A Form 1 can be applied when a licensed physician believes that the patient has either threatened or attempted harm towards themselves or others through action or neglect due to psychiatric causes. Note that for non-psychiatric medical causes, such as brain injury resulting in cognitive impairment, a patient can be detained without a Form 1. Although the signing physician must personally examine the patient within seven days prior to a Form 1 being signed, any physician can perform the said exam under sections 15.1 and 15.2 of the Ontario Mental Health Act (OMHA). A police officer who has suspicions similar to those outlined above may take a person into custody under section 16 of the OMHA, but must facilitate an evaluation by a physician as soon as reasonably possible, and the physician may then fill a Form 1. In the event that the patient is in the community when a Form 1 is signed, delivery of the patient to a facility with psychiatric in-patient services (also known as a schedule 1 facility) can be facilitated by anyone, citizen or law enforcement official, within the seven day expiration period. In London, schedule 1 facilities include: Victoria Hospital, University Hospital, St Joseph's Health Care and Regional Mental Health Care – St Joseph's.²

FORM 1 USE AND ITS OUTCOMES

On a Form 1, the physician must outline the findings that have contributed to suspicion of a mental disorder, including facts that were reported by collateral sources such as the police or family members (section 15.3).¹ Upon the completion of a Form 1, the patient can be held without consent in hospital for up to 72 hours in order to facilitate a complete

evaluation (section 15.4). On a Form 1, the physician must select either "Box A – Serious Harm Test" or "Box B – Patients Who are Incapable of Consenting to Treatment and Meet Specified Criteria".³ Box A focuses on past, present and future risks or threats of harm to themselves or others. If Box A is used, the patient can be held for exam as described above, but treatment cannot be provided without consent. Box B on the other hand is used for patients who meet the following criteria: 1) they have an established mental diagnosis that has improved with treatment, 2) without treatment they are incapable of consenting to treatment (recognizing that with treatment they may or may not be incapable of consenting to the treatment), and 3) they pose a risk to themselves or others. By completing Box B, the physician affirms that under the Health Care Consent Act, the patient is incapable of consenting to treatment and a substitute decision-maker will be consulted (in relation to the relevant psychiatric treatment). It is worth noting that due to the fact that Box B requires considerable background knowledge about the patient, its use in the emergency department is rare. The vast majority of Form 1 applications by non-psychiatric physicians are made using "Box A".

In addition to a Form 1, the physician must also complete and provide the patient with a Form 42, which is a notice to APA, meant to inform the patient that he or she is being held in hospital and the reasons for this decision. A Form 42 outlines the patient's right to contact a lawyer without delay and the responsibility of the hospital to aid that contact. The Act does not mandate that the physician read the patient their rights or notify a rights advisor about the involuntary detainment under a Form 1 (a rights advisor is legally required to be notified by the physician for instances of involuntary admission as with a Form 3 and a Form 4 per the OMHA). However, the physician should inform the patient of the current therapeutic plan and that the patient will remain in hospital until a psychiatric assessment can take place by a certified psychiatrist. In contrast to an involuntary admission decision under section 20 of the OMHA, a patient on a Form 1 does not have the right to appeal a Form 1 decision to the Consent and Capacity Board.

Following the 72 hour evaluation period, there are three possible outcomes to Form 1 use: the patient can be released, the patient can be admitted voluntarily under section 12 of the OMHA, or the patient can be involuntarily admitted to a schedule 1 facility following the completion of a **Form 3** by a physician under section 20.1.1 of the OMHA.¹ Note that if a decision is made to involuntarily admit, the admitting physician cannot be the same one who completed the Form 1.⁴

FORM 1 USE AND MEDICO-LEGAL CONSIDERATIONS

We found no precedent of a physician having successful legal action brought against them for the use of a Form 1. This may be due to the fact that patients cannot appeal the application of a Form 1, and that the short duration of a Form 1 can be considered to result in only a minor

Form 1: Application for Psychiatric Assessment (ASA)

Completed when a physician believes that due to a mental health condition, a patient:

- Has attempted harm to others or themselves
- Has threatened harm to others or themselves
- Is unable to care for themselves

Rights of the patient:

- To be immediately given a **Form 42** outlining the reasons for being held in hospital
- To be assessed for a period of no more than 72 hours, during which they receive a formal psychiatric evaluation
- To contact a lawyer without delay

Responsibility of the physician and hospital:

- Facilitate the patient's rights outlined above.
- To not provide treatment without informed consent under Box A.
- Explain the patient's rights and situation.

Results of a Form 1 after no more than 72 hours:

- Patient is released back into community
- Patient is admitted voluntarily
- Patient is admitted involuntarily upon completion of a **Form 3**

A Form 1 expires 7 days after being signed. A physician can only sign a Form 1 if they have personally examined the patient.

A Form 1 can be found at: http://www.health.gov.on.ca/en/public/forms/mental_fm.aspx

Figure 1: Quick guide to Form 1

restriction of freedom and hence of minor legal importance. Referring to limiting physicians' liability in cases of involuntary detainment of longer duration, the Canadian Medical Protective Association recommends that physicians continue to exercise their judgement and opinion honestly and in the best interest of the patient and others.⁵ This recommendation could be applied equally well to the application of the Form 1, even if there is no legal precedent of actual liability in these cases.

THE INVOLUNTARY PATIENT

In the event that there is reasonable cause to suspect that a patient may cause harm to themselves or others in the near future, such as in J's case, an ER physician will likely wish for the patient to undergo a psychiatric assessment (PA). Importantly, this may occur voluntarily or involuntarily if the physician deems it necessary. A Form 1 is only required for involuntary detainment of a patient.

In order to be an acceptable voluntary candidate, the physician must be reasonably confident that the patient will comply with instructions and is unlikely to cause harm. This assessment includes the consideration of several factors, such as suicide, harm to others, self-harm and self-care. Further, the severity and intensity of risk-related thoughts, formulation of dangerous plans, access to lethal means, level and competency of supervision and willingness to contract for safety (an agreement the patient makes to seek help before acting on self-harm or aggressive impulses) are important factors to consider. In addition, the patient's support system is an important factor and the absence or withdrawal of this support may be a deciding factor for the patient's involuntary detainment.⁶ It is important to note that meeting the above criteria hinges

on the experience and comfort level of the physician with identifying risk factors and dealing with high risk psychiatric situations.

Hence, to use a Form 1, the patient must not be an appropriate voluntary candidate. This is decided on the basis of weighing the complex interplay of social, psychological and medical variables in the patient's life. To some degree this assessment may be influenced by the ER physician's experience and the practical demands of running a busy ER department.

GROUNDINGS FOR PATIENT DETAINMENT

The decision to involuntarily detain a patient balances the restriction of a patient's liberty and the need to safeguard the patient and/or society. This may result in stigma or emotional trauma to the patient from the restriction of freedom. This is a significant social and moral matter, considering there are only a handful of circumstances in which our society permits such restrictions against an individual, such as during criminal proceedings.

The implied rationale for detainment is that the short-term cost to the individual is acceptable to society at large to help prevent future harm. This is a significant matter, considering that a patient may be detained even if they have not performed any harmful actions, such as in J's case. The patient may merely be suspected with reasonable cause by the physician to be likely to carry out harmful actions in the near future. Indeed, the criteria for Form 1 use are broad and non-specific, and can be applied to many patients, sometimes even in situations where the necessity of the use of a Form 1 is debatable. This large amount of power given to physicians in the legislation can serve the patient and society well if applied judiciously. Conversely, if it is applied in a less than conscientious manner, there is potential for abuse or negligence.

Additionally, there are inequalities relating to the time frame of the Form 1. For example, in a major urban centre where psychiatric care is readily available, the patient will often receive a psychiatric assessment within several hours of medical clearance and will not have to be admitted into hospital. However, in underserved regions, access to a psychiatric assessment may be difficult and the patient may be admitted to a non-psychiatric facility (a non-schedule 1 facility) while he or she awaits a psychiatric assessment.⁶ In fact, under the law there is no limitation to the repeated use of Form 1 to detain patients for longer than 72 hours.

In the above-noted case, J was detained under a Form 1 and was released following a psychiatric assessment and the completion of a treatment plan. Still, in some cases, patients who are detained involuntarily incur an individual cost, in spite of the legally-based assumption that this will protect society or themselves. The decision to utilize a Form 1 should not come lightly and must adhere to all the requirements outlined here. A Form 1 entrusts physicians with significant powers based on the legislature's trust that they will abide by stringent principles in the decision-making process.

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Medical and economic benefits of chest pain units in the diagnosis and treatment of acute coronary syndrome

Tommy Choy (Meds 2015), Jessica Jackson (Meds 2015)

Faculty Reviewer: Dr. Lois Champion, M.D., FRCPC, Department of Anesthesia/ICU

ACUTE CORONARY SYNDROME

Acute Coronary Syndrome (ACS) is a general term used to describe a spectrum of life-threatening conditions affecting the heart and circulation. In ACS the heart's blood supply becomes suddenly restricted by the formation of a thrombus in the coronary arteries. Depending on the severity of the blood clot, a spectrum of heart conditions can occur. This spectrum ranges from minor chest pain (angina) to major cardiac events including myocardial infarctions.¹

A number of risk factors are associated with the development of ACS. These include smoking, obesity, hypertension, diabetes, dyslipidemia and aging. As the prevalence of these risk factors increase within Canadian society, the societal cost of ACS continues to increase.¹

DIRECT MEDICAL COSTS OF ACS

Affecting approximately 100,000 Canadians each year, ACS is currently the second leading cause of death in Canada. In 2008-2009, there were 109,109 hospitalizations due to ACS and over 21,000 deaths.¹ Although a large proportion of deaths from ACS occur before the patient reaches the hospital, emergency rooms are the primary sources of treatment for Canadians presenting with ACS.²

A combination of numerous factors, including severity of the ACS event, hospital resources, and local clinical practice determine the total direct medical cost of ACS. With these variances in mind, the national average hospitalization cost for a heart attack in 2008-2009 was found to be approximately 10,000 dollars and the national average for treating acute chest pain was approximately 4,500 dollars. Representing a total annual direct cost of over 1.5 million dollars each year, ACS is clearly a large burden on Canada's finite medical resources.¹

ECONOMIC COSTS

In addition to the direct medical costs outlined above, ACS also represents a significant burden on Canada's economy. Productivity losses in the form of premature retirement, increased sick leave and death of qualified workers all contribute to a decrease in national Gross Domestic Product. ACS is responsible for 1.3 days of sick leave per year contributing a cost of 1.8 billion to the Canadian economy in 2008-2009.¹ Representing approximately 0.12% of the 2009 gross domestic product of Canada this economic cost is clearly placing a significant burden on Canada's economy.¹

CURRENT TREATMENT STRUCTURES

Depending on the severity of a patient's presentation, numerous diagnostic and medical procedures are performed in hospital to treat each patient presenting with ACS. ACS is currently treated using procedures, lab tests, risk stratification and recommendations about lifestyle changes depending on each patient's presentation. Different centers across

Canada have unique procedures for ACS triage and treatment.³ The individualized method common to most emergency rooms has however been found to be only 73.8% sensitive for detecting cases of ACS. In fact, Christenson et al. found that the average Canadian emergency room misses 5.3% of ACS cases and that considerable health care resources are expended on inefficient diagnostic and treatment procedures.³ This article discusses the medical and economic benefits of a new form of ACS triage - Chest Pain Units.

CHEST PAIN UNITS (CPU)

Numerous methods have been developed over the years in response to the unsatisfactory diagnostic quality of Acute Coronary Syndrome (ACS) identification in emergency departments. The chest pain evaluation unit, or chest pain unit (CPU), is an area within the hospital or the emergency department itself that is used to reduce inadvertent discharge of patients with low to moderate risk of ACS. While many different protocols are adopted across hospitals, CPUs try to identify acute myocardial necrosis, rest ischemia, and exercise-induced ischemia.⁴

Within the CPU, patients are assessed using past history, risk factor identification, physical examination, serial ECGs and serial evaluation of cardiac biomarkers. Patients are usually kept in the unit for a minimum of 6 hours and may be observed for as long as 18 hours, depending on the test results. Patients with positive test results for serial markers, such as the level of high sensitivity troponin, are admitted to the hospital for further evaluation.⁵ Those with a negative result may be referred for further testing, such as graded exercise testing, stress nuclear imaging or stress echocardiography.⁴

COST EFFECTIVENESS

In the United Kingdom and United States, many studies have been done to examine the cost effectiveness of chest pain units. In these studies, costs included both direct and indirect medical costs, and the effect measured is the quality adjusted life year (QALY) gained.^{6, 7, 8} From an economic viewpoint, a cost effective intervention should provide positive incremental value. Within this, interventions that provide an increased benefit at a lower cost are considered dominant and should be adopted; while an incremental cost effectiveness ratio (difference in costs/difference in effects) should be calculated for treatments that are more expensive.

In the past decade, many single center studies were done in the USA that compared the use of CPUs with hospital admission for patients with low to moderate risk of ACS. These studies all found the CPUs to be more cost effective than hospital admission. More recently, studies were done that compared the use of CPUs with standard care based on the expertise of the emergency department staff. These studies are more likely to estimate real differences due to the fact that not all patients receive

HEALTH POLICY AND ECONOMICS

ing care become inpatients. In one single center study conducted in the UK, it was found that CPUs reduced the number of admissions to the hospital and improved health utility.⁷ CPUs were also associated with an increased cost of 2,750 pounds (or 4300 dollars) per QALY gained, but this was well within the value of 20,000-30,000 pounds per QALY recommended by the National Institute of Clinical Excellence. Overall, the study estimated a 95% probability that CPU will be cost effective.⁷

Subsequent multicentre studies in the UK, however, were unable to reproduce the findings. The Effectiveness and Safety of Chest Pain Assessment to Prevent Emergency Admissions trial showed that CPU care did not reduce the number of patients admitted and may even increase admission from emergency and other routes.⁶ Another study investigated whether or not CPU care may be cost effective by improving health outcome and reducing cost in other ways. The study did not find any significant differences in health outcome between CPU care and routine care and only estimated a 70% probability of CPU being cost effective.⁶ These studies are subject to many uncertainties and more research is recommended to ascertain whether or not the immense capital required for implementing CPU care is justified.

STATUS IN CANADA

In contrast to USA, CPUs are not widely adopted in Canada, nor have there been studies comparing use of a CPU with the current unstructured approach across hospitals. When compared with the United States, there is evidence suggesting that the current approach is unsatisfactory due to a higher than accepted rate of missed patients from early discharge.³ In partial response to this, British Columbia has begun recommending patients with possible ACS be observed in the ED and undergo serial testing for cardiac biomarkers.⁹ Nevertheless, additional evidence is needed to convince administrators and clinicians across the country that CPU models can be cost effective. This is particularly difficult given the lack of common baseline performances between emergency departments in Canada.

OTHER METHODS TO IMPROVE DIAGNOSIS

Given that CPU itself is a response to the diagnostic uncertainty encountered in the ED, improvement of current diagnostic methods or strategies in the ED is also a viable option in improving patient outcome. One method that has been studied is the use of point of care (POC) biomarkers as opposed to serial testing in patient risk stratification. In one hospital in Thunder Bay, it was reported that the introduction of POC biomarkers helped to reduce admission and saved costs.¹⁰ In another multicentre trial, the use of POC assessment was linked to reductions in hospital admissions, but the associated cost was greatly increased such that the probability of it being cost effective was less than 10%. This was due to the increased use of cardiac interventions associated with POC biomarkers.¹¹ Further research is needed to evaluate whether or not these increased interventions result in additional patient benefits.

Similar to POC testing, Cardiac Computed Tomography (CCT) has also been explored as an alternative to the current standard care. A single center US study done recently included both ED costs and downstream costs associated with CCT, and it found that CCT had a 99% probability of costing less than the standard of care testing.¹² This was primarily due to the differences in cost between CCT and stress testing, particularly when stress nuclear imaging was used in the standard care. Although promising, there are limitations associated with the use of these imaging techniques, such as increased radiation exposure and decreased performance in patients with high body mass index.¹³ In addition, there is great variability in diagnostic accuracy across centers with this technique, which needs to be addressed before universal adoption.¹⁴

CONCLUSION

Currently, there is no single optimal evaluation protocol across hospitals that can accommodate for the differences in local resources and expertise. In addition, there is insufficient evidence to advocate for the formal implementation of chest pain units in Canada. Further research in this area is recommended in order to improve the outcome of patients with suspected ACS.

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Breastfeeding promotion: the NICU perspective

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Breastfeeding is recognized as the best source of nutrition for all infants, and the World Health Organization (WHO) recommends exclusive breastfeeding until 6 months of age.¹ Breast milk provides protection against infection, autoimmune disease, and gastrointestinal dysfunction, and promotes cognitive development.² The beneficial effects of breast milk can be seen even more clearly in preterm and low birthweight infants being treated in the Neonatal Intensive Care Unit (NICU), where infection and neonatal sepsis are more common. These babies will also benefit from the analgesic properties of breastfeeding during medical procedures.¹ However, studies have shown that breastfeeding rates for low birthweight infants are lower than their normal birthweight counterparts.³

In order to promote breastfeeding in hospitals around the world, the WHO has developed the “Baby Friendly Hospital Initiative” (BFHI). This initiative provides ten steps that must be achieved before a hospital can be formally accredited with BFHI status. Many successes have been seen since the program’s implementation, including an increase in breastfeeding initiation and duration, and a decrease in incidence of neonatal infection and atopic eczema.⁴ In Canada, the rate of breastfeeding at discharge is now at 80%, although exclusive breastfeeding rates remain low.¹

BFHI has shown success in all hospital units, including the NICU. An Australian study showed that, 4 years after implementation, breastfeeding initiation rates in the NICU rose from 35% to 75% and exclusivity at 2 weeks from 10% to 40%.² However, there has been trouble implementing all ten steps in the unique NICU environment. For example, the steps include allowing mothers and babies to room together and discouraging the use of artificial pacifiers; these steps are often impossible in the NICU, where there are no individual rooms and pacifiers are used to promote oral motor skills in premature infants.⁴ It has been suggested that the WHO develop a subset of BFHI steps specifically for the NICU to provide guideposts for health workers and administrators.⁵

Breastfeeding promotion in the NICU faces a unique set of challenges. Because many of the infants are premature, oral motor skills are often poorly developed and these infants may display an inability to latch and suck.^{5,6} This means that mothers must often use manual or electronic breast pumps to express milk, which is then fed to the infant by gavage or oral feeds. The lack of direct suckling, combined with the obvious stresses of having a sick infant, cause the mother’s milk supply to quickly decline.⁶ To achieve an adequate milk supply, mothers may have to pump for over 2 hours a day, which can itself be stressful and exhausting.² As well, the lack of electronic breast pumps and privacy screens in the NICU can discourage mothers from attempting to breastfeed.⁵

A 2007 study of factors influencing breastfeeding in the NICU found

that a lack of systemic, consistent advice prevented mothers from initiating and maintaining breastfeeds. Women reported that, while many NICU nurses were knowledgeable, they had never discussed breastfeeding with their obstetrician or neonatologist.³ This was echoed in another study, in which mothers reported that they received great help from lactation consultants, but did not feel that physicians were supportive.⁷ Many NICU staff still promote formula feeding, and formula companies still sponsor many of the educational lectures on neonatal care.⁵

Another barrier to breastfeeding is the design of NICUs, which do not promote alone time or skin-to-skin contact between mothers and infants. A recent study found that only 16% of infants in the NICU were held skin-to-skin with their mothers, a practice which has been shown to increase breast milk quantity.³ Because the NICU is more medicalized than other maternity wards, the focus seems to be on breast milk as a product instead of breastfeeding as a natural process beneficial to both mother and infant.⁷

Several strategies have been employed to try to counter the inherent challenges of breastfeeding in the NICU. In response to mothers’ complaints that their attempts at breastfeeding were being undermined by the negative attitudes of and inconsistent advice from NICU staff, one hospital implemented an educational intervention designed to improve the breastfeeding knowledge of NICU nurses.⁸ After the 8-hour educational session, which covered breastfeeding theory and techniques, an analysis of pre- and post-intervention questionnaires revealed a significant increase in breastfeeding knowledge compared to control nurses from other wards who did not attend the education session.⁸ The authors suspected that the increased number of mothers providing breast milk for their infants at the time of discharge from the NICU during the year following the intervention was related to the nurses’ improved knowledge.⁸ A series of focus groups with NICU nurses in Australia revealed the perspective that staff education was also the key to improving the confidence of nursing staff so that they could feel more comfortable promoting breastfeeding to both mothers and other colleagues, including doctors.⁵

In some settings, mothers of NICU infants may benefit from additional support beyond what is provided by staff; one study found that having access to a peer counselor (a woman from the local community with breastfeeding experience who had attended a 5-day breastfeeding course) led to 181% greater odds of breastfeeding at 12 weeks compared to mothers who only received the standard of care ($P=.03$).⁹ Peer counselors provided verbal advice or physically helped the mothers to breastfeed, pump, and engage in skin-to-skin holding over a 6-week period.⁹

One hospital in West Virginia took the opportunity to evaluate the impact on breastfeeding rates when it re-designed its NICU from a more traditional open-bay ward with multiple neonates in a large room to a

HEALTH PROMOTION

single family room (SFR) unit with a private room for each neonate. After the re-design, 20% more infants were discharged from the NICU breastfeeding, and infants in the SFR received maternal breast milk on 90% of days spent in the NICU compared to 66% of days for neonates who stayed in the open-bay ward.¹⁰ This improvement may have been owed to the more private, tranquil environment of the SFR unit, which should have enabled mothers to spend more time with their infants and engage in more skin-to-skin contact.¹⁰

Whenever new hospitals are built or NICUs are renovated, designers should attempt to maximize privacy and comfort for mother-infant pairs to promote breastfeeding, pumping, and skin-to-skin contact. However, limited visiting hours and having to travel large distances between home and the hospital many continue to present significant challenges for mothers in some settings.¹¹ Hospitals should ensure that all mothers with an infant in the NICU have access to a high quality electric breast pump at home to maintain lactation when the mother and infant are separated.²

Despite the many barriers to successful breastfeeding that are present in the NICU, it is possible that the prolonged hospital stay may provide an important opportunity for enhanced maternal breastfeeding education compared to other maternity wards where infants are discharged from the hospital soon after birth.⁵ This opportunity can be augmented through the strategies discussed above, namely improved staff education and a peer counseling program.

The NICU at London Health Sciences Centre (LHSC) uses a variety of approaches to encourage mothers to breastfeed their infants.¹² The majority of NICU rooms have only two infant beds and curtains that can be drawn for further privacy. Mothers are able to breastfeed, pump, or engage in skin-to-skin contact in their infant's room, or can choose to go to a separate room where several electric breast pumps are available. Visiting hours do not apply to mothers, who are able to stay with their neonates around the clock. Mothers are able to stay on the hospital grounds or in the NICU itself, eliminating the burden of having to travel large distances between home and the hospital. However, some mothers with other children at home may not be able to spend as much time at LHSC.

In addition to the support and advice that mothers receive from the NICU's Lactation Consultant, they are provided with several pamphlets with breastfeeding and pumping instructions, as well as charts to record milk volume. These pamphlets and information sheets are available in several languages, and interpreters are also available if necessary. Mothers are encouraged to rent hospital-grade electric breast pumps, and a loan program exists for mothers who cannot afford to do so. In an effort to be as inclusive as possible, non-electric foot peddle-operated breast pumps are available for Mennonite mothers who do not have electricity at home.

While the LHSC NICU discharges the vast majority of its neonates breastfeeding, it remains a challenge to get mothers to continue breastfeeding once they return home. This year, the hospital will begin running a post-discharge nutrition clinic so that high-risk infants and their families can return for further support. Despite its many successful practices, LHSC has not yet complied with all of the BFHI requirements. One major barrier to this achievement is that infant formula companies are still allowed to provide their product for free at LHSC (health care facilities must purchase formula to be BFHI-certified).

The importance of breastfeeding for all infants, and NICU infants in particular, has been recognized around the world. The BFHI has provided hospitals with guidelines that can be used to promote breastfeeding to mothers and staff alike. Even though the NICU poses certain challenges, creative solutions have been identified to increase breastfeed-

ing rates and duration in this environment. The use of electronic breast pumps, increased staff education, and single family room design have all been shown to increase the comfort and frequency of breastfeeding in the NICU. Many of these solutions have already been used a LHSC, which has resulted in high rates of breastfeeding on discharge. Hopefully, widespread implementation of some of these solutions can help promote the use of breast milk in all hospital NICUs.

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Interdisciplinary collaboration and relevant perspectives in critical care: suggestions to the medical student

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INTRODUCTION

Interdisciplinary collaboration plays an important role in the provision of health care. This role is even more pronounced in intensive care settings where nurses, physicians, and other health professionals work more closely together than other areas of the hospital. Numerous articles in the medical literature suggest that collaborative practice in intensive care units (ICUs) is essential to reduce patient morbidity/mortality and improve patient outcomes.¹ Collaborative practice has the additional benefits of reducing health care costs and improves job satisfaction for the members of the interprofessional team.¹ While the benefits of physician-nursing collaboration in the ICU are well described in the literature, there are gaps when translating these principles to clinical practice. This article aims to describe current collaborative practices in the ICU and discusses the barriers and challenges associated with this practice model. Furthermore, we make recommendations geared towards medical students to improve collaborative practice in the ICU setting.

The meaning of 'collaboration' or 'collaborative practice' is not clearly defined in critical care literature. Weiss & Davis model is commonly used, and describes collaborative practice as interactions between nurse and physician that enable the skills and knowledge of both professionals to synergistically influence the patient care being provided.^{1,2} That is to say, collaborative practice occurs when professionals work together to provide patient care.

CURRENT COLLABORATIVE PRACTICE IN CRITICAL CARE SETTINGS

Currently, collaborative practice and teamwork amongst interdisciplinary teams relate primarily to sharing of responsibility. Little emphasis is placed upon coordinating decisions based on input from team members.³ Consequently, team practices tend to occur in a parallel, multidisciplinary manner, instead of involving all team members in decision making as desired by interdisciplinary collaboration. Efforts to improve collaboration have sought to implement 'potentially better practices (PBPs)', defined as evidence-based practices that have been shown to improve outcomes in one setting, and which can be selected, modified and applied in unique ways to fit a new situation.⁴ In one study, five centres were involved in a focus group studying neonatal ICU (NICU) environmental design and its impact on the neurodevelopment of neonates.⁵ The group identified 16 PBPs using an evidence-based approach, including tactile stimulation and developing a system for noise assessment of the NICU acoustic environment. Collaborative development and sharing of educational tools played a crucial role in successfully implementing these PBPs and involved multiple professions within the intensive care environment.⁵ Moreover, the importance of interdepartmental collaboration was identified when taking suggestions from multiple caregivers regarding noise sources in the neonates' environment.⁵

Furthermore, specific positive effects of interdisciplinary collaboration interventions have been documented in intensive care settings.⁶ One study evaluated the effectiveness of collaborative decision-making processes on the process of weaning from mechanical ventilation in a medical intensive care unit.⁷ Outcomes measured included length of time on mechanical ventilation, length of stay in the intensive care unit and cost. The study found decreased length of stay in the ICU and length of time on the ventilator with the collaborative weaning group. There were no significant changes in cost observed.

Another study found improvements in quality and reduction in cost of neonatal intensive care after an interdisciplinary collaboration intervention. Teams from NICUs received instruction in quality improvement, reviewed performance data, identified common improvement goals, and implemented 'potentially better practices' developed through analysis of the processes of care, literature review, and site visits. A decrease in hospital costs was observed within the year following the intervention.⁸ It is important to note that these studies may be limited by the lack of long-term longitudinal studies to examine sustained positive effects, but suggest there are both system and patient benefits to interprofessional collaboration. In general, collaboration has led to better patient outcomes, including reduced morbidity and mortality rates,¹ and reduced nosocomial infections in ICUs.⁹

BARRIERS AND PERSPECTIVES OF COLLABORATION IN CRITICAL CARE

It has been suggested that the attitudes of health care professionals involved in collaborative practice in critical care are pivotal to its success. Therefore, negative attitudes can easily be detrimental and adversely affect patient care.^{1,2} For example, one study found that few health care professionals are willing to accept questioning of their decisions, especially from the nursing staff.¹⁰ This leads to nurses further deferring to physicians, creating conflict between the desire to be accepted and duty to advocate for the patient.¹¹ The authors of this study suggest that this internal conflict, combined with varied degrees of responsibility and overlapping competencies can lead to 'role blurring' and confusion of one's expected role within the team.^{12,13} Unfortunately, the professional culture of health care has traditionally promoted hierarchical structures with the physician in control, directly conflicting with the cited prerequisite of equal status amongst team members.^{12,14,15}

While interprofessional collaboration is often welcomed and necessary in the intensive care setting, perspectives differ between each of the professions involved. This difference often originates from the identity of each profession.¹² The professional identity, including cultures, beliefs, attitudes, and behaviours, becomes ingrained during the training process, and shapes the provider's own problem solving approaches, values, language, and perception of his/her role in a team.¹²

INTERDISCIPLINARY

Medicine and nursing are two professions with increasingly overlapping scopes of practice that interact frequently during ICU care. However, the two professions are trained in different manners. Physicians are trained to collect information and generate differential diagnoses, and to evaluate patient outcomes in the context of the treatment plan.¹² Nurses are traditionally trained to collect data, often simultaneously with physicians, offer observations and impressions, and advocate for the patients and families during their time in the ICU.¹² For example, when the patient requires a prolonged length of stay in the ICU, the physician's scope of practice is often de-emphasized, and the role of the nursing and other health professionals is highlighted e.g., weaning from mechanical ventilation, early mobility, family and patient support.^{16,17}

Due to the differences in professional identities and educational training, miscommunications often arise during physician and nurse interactions. Nurses may find that when collaborating with physicians, physicians are unwilling to accept their input or to make changes. On the other hand, physicians may perceive nurses as defensive or aggressive in telling them what to do for the patient.¹⁸ In some cases, physicians may perceive collaboration as having taken place, while their nursing colleagues disagree.¹⁹ Miscommunication of differing perspectives can create treatment plans that fail to address the concerns of each profession, and negatively affect the patient and family's hospital stay. Additionally, collaboration may not be prioritized due to the time needed for effective communication and coordination in addition to heavy clinical workloads.²⁰ Despite these challenges, several things can be done to overcome barriers and foster a collaborative work environment

Research studies have shown that three broad elements are necessary for collaborative practice: clinical expertise, open communication/sharing of knowledge, and a relationship based on trust, empathy and respect.^{18,21-23} These elements are essential for unifying perspectives and attitudes, and resolving conflicts during collaboration. It is worth noting that the majority of clinical training is geared towards the development of clinical expertise and little emphasis is placed on the development of "soft skills" including communication, collaboration and conflict resolution. Many students develop their soft skill set through personal experiences and the 'hidden curriculum' of each profession. Practicing professionals are able to profoundly influence the collaborative approach of students through their own actions and attitudes.

RECOMMENDATIONS AND CONCLUSIONS

As medical students, we will be working with many different health care professionals during our training. Thus, we will have many opportunities to develop collaboration skills, and seek feedback on these skills from both physicians and other members of the team. Unavoidably, we will encounter experiences that negatively affect our views of another profession, and vice versa. Before letting a recent 'negative experience' colour our perceptions, we should reflect on the experience through an alternate point of view. Through interactions with students and professionals, we should strive to improve our collaboration skills to positively impact patient outcome and personal satisfaction. We should also seek to gain an understanding of other health care professionals' perspectives, and to serve as representatives of our profession. After reflecting on the benefits of having collaborated with others, both in personal and professional aspects, we are compelled to further advocate for interprofessional collaboration.

Emphasis has been placed on interprofessional education in the academic setting as a strategy for physicians to develop collaboration and communication skills.²⁴ However, collaborative models enacted in the acute care settings continue to be the exception. This is possibly due to the lack of education and time dedicated to unifying perspectives, as well as absence of rewards or incentives to practicing within such a

model. In order to encourage interprofessional cooperation within the acute care setting, educational programs that promote opportunities for multiple disciplines to work together towards a common goal have been recommended.²⁵ This may include simulation exercise, or other team activities as part of education and training that highlight collaboration as a formally evaluated objective. Unfortunately, the majority of training continues to be provided in isolation, supporting the idea of independent roles and responsibilities within the health care system.

Lastly, we must be aware of our responsibility to foster teamwork in our learning environments. We need to be active in seeking feedback from preceptors and coworkers regarding our abilities to effectively communicate and collaborate as we continue our educational journey. By placing more attention on the perceptions and attitudes of professionals and creating environments that encourage professional understanding, we can begin to cultivate collaboration in the intensive care unit, and beyond. This will allow health care professionals, patients and families to profit from the established benefits of collaborative practice.

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The future of emergency medical care: novel technological approaches for improved patient management

Laura Callan (Meds 2015) and Melissa J. MacPherson, Ph.D. (Meds 2014)

Faculty Reviewer: Christine Richardson, MD, CCFP(EM) (Department of Emergency Medicine)

Imagine the plausible scenario of a single motor vehicle collision on a rural highway north of London, Ontario. The 37 year old driver, Willie McKeet, is the sole occupant in the vehicle traveling at approximately 80 km/hr. Without warning, a deer jumps out of the bushes in front of his car. Panicking, Mr. McKeet swerves to avoid the deer, loses control of his car and hits a tree head-on. Another motorist witnesses the collision and pulls over to assess the situation. She finds the man unconscious with lacerations on his forehead. The front airbags have deployed and he had been wearing his seatbelt. She calls 9-1-1. A few minutes later, an ambulance arrives on the scene of the collision. As the paramedics are removing Mr. McKeet from his vehicle they notice redness and bruising on his left shoulder and what appears to be the deformity of his right hip. Willie is loaded into the ambulance and driven to the nearest regional hospital--a 20 minutes trip.

Health care technologies are constantly evolving and their judicious use can improve patient care and hospital efficiency. In this article, we will describe several novel technological approaches to managing urgent patient care that may be adapted in the not too distant future. We will follow the management of Willie McKeet from the scene of a single motor vehicle collision through to the operating room and explore these emergent technologies along the way.

Use of emerging emergency care technologies will not begin when Mr. McKeet reaches the emergency department (ED), but rather in the ambulance during transport to the hospital. Traditionally, during transport, very little could be done for this patient. The paramedics would assess his vitals, control his bleeding, perform life-preserving support as necessary and notify the hospital of their impending arrival. The futuristic paramedics who arrived on the scene of Mr. McKeet's accident, however, were equipped with an ED-link system. This system consists of two-way audio, video and data transfer between the paramedics in the ambulance and the emergency room staff at the nearest hospital.¹ The portable camera allows the paramedics to send the ED staff real-time video of the crash scene, allowing them an opportunity to better gauge the extent and type of injuries that Mr. McKeet may have sustained. The live two-way voice and video also allows Dr. U.L.B. Fine, the ED physician who will be treating Willie, to better ascertain the situation by communicating directly with the paramedics.

During the twenty minute drive to the hospital, Dr. Fine and the paramedics are in constant communication. The paramedics monitor Mr. McKeet's vitals and determine that his blood pressure is slightly decreased, while his heart rate and respiratory rate are slightly elevated. They then begin to assess his injuries. Willie has lacerations on his forehead and bruising on his left shoulder that continues diagonally across his chest. Dr. Fine determines that the patient will need a head CT and chest X-ray. A call is placed to the Radiology Department to check the availability of the CT scanner and X-ray machines and alert them of the

patient's imminent arrival. While continuing down the body, the paramedics note the deformity of the right hip as well as inflammation across his lower abdomen where the lap belt had apparently been sitting too high and caused constriction during impact. Dr. Fine, concerned about both of these findings, asks the paramedics to use their portable ultrasound to take a look at the abdominal cavity and determine the extent of any internal bleeding or intestinal devascularisation, common with seatbelt injuries.² Using the Focussed Assessment with Sonography for Trauma (FAST) setting on their MobiUS device, a smartphone-based ultrasound imaging system,³ the paramedics are able to image both the abdomen and hip.^{2,4} With a click of a button, the paramedics send the raw video to Dr. Fine who is able to determine that there is free fluid around Mr. McKeet's liver and spleen. The Trauma Team leader is notified and a resident, Dr. Tired, is sent to the ED to assess the patient when he arrives at the hospital. Furthermore, Dr. Fine and the radiologist determine that the muscles and ligaments around Mr. McKeet's hip have not been damaged and that pelvic radiograph is not immediately needed upon arrival thus, saving time and resources and allowing the staff to focus on his other injuries.

By the time the ambulance arrives at the Emergency Department much has already been done. Mr. McKeet has been checked-in electronically by the paramedics en route to the ED using a hand held computer linked up to the hospital's computer system.⁵ His electronic health records have already been retrieved by Nurse Amy, an ED nurse, onto a tablet computer giving immediate access to all his health information. She knows that he is allergic to penicillin, is currently taking metformin to control his type II diabetes and has type A negative blood. His emergency contact information is readily accessible and his family can be contacted and informed of his situation. Nurse Amy is able to communicate this information to the rest of the team as Mr. McKeet is being wheeled into the trauma bay. The imaging results collected by the paramedics are also automatically displayed on hand held tablets for further review by the ED staff. The team knows that Willie has abdominal bleeding and requires further imaging once stabilized. They initiate the plans they have made to acutely manage his injuries until he can get to an operating room. Nurse Amy has prepared several units of A negative blood for transfusion since Dr. U.L.B. Fine knew Willie would be requiring a blood transfusion based on his condition in the ambulance relayed by the ER-link system. Once in the ED, telemetric technology is used to monitor Mr. McKeet's vital signs.^{5,6} These data are automatically displayed on computer screens in the trauma bay and uploaded into his electronic medical records. Once Mr. McKeet has been stabilized, he is sent for CT head and C-spine as well as CT thorax, abdomen and pelvis. Traditionally, tracking down a patient in the hospital is a difficult task during treatment; however, when Willie's family arrives panicked in the ER, Nurse Amy is able to activate the electronic tracking device that was placed on his hospital bracelet and inform the family that Willie

is currently on his way from the radiology suites back to the ED.⁵ The results of Mr. McKeet's CT scans are automatically sent to his electronic health record and are viewed by Dr. Tired, the trauma resident, on his tablet computer as he awaits Willie's return to the ED. After surgical consultation, Mr. McKeet is sent to the operating room for surgery.

The utility of the novel technologies continues into the operating room. Mr. McKeet's imaging results are displayed on large flat screen monitors for reference during the surgery. The operating room staff use hand held tablets to complete surgical and procedural checklists⁷ which are automatically linked to Willie's electronic health record. After the checklists are complete, Dr. Drugs, an anaesthesiologist, uses hand-held computing applications to verify drug information and calculate doses for the surgical procedure.⁸ Once Willie is under anesthesia, the surgery begins. The procedure is automatically filmed using a digital camera⁹ and a copy is linked to the electronic health record. The video can be reviewed by the surgeons for training purposes, quality control measures, research purposes or in case of legal action. After surgery, Willie's lab results and further tests are continuously updated in his electronic health record. Upon discharge Mr. McKeet's family doctor can review Willie's electronic health record for a detailed chronicle of his hospital stay, allowing for seamless continuity of care.

These technologies may seem futuristic; however, several are already in use. In a Boston Emergency Department, the SMART system has been used to successfully monitor patient vital signs and track patients using a geo-positioning system.⁵ Likewise, telemetric care has been successfully applied to various clinical scenarios including the assessment of stroke patients while en route to hospital,¹⁰ remote consultation with neurology specialists from large academic centres¹¹ and 12-lead EKG transmission from ambulances to cardiologists.¹² The application of telemetric technologies would be especially useful in regions such as Southwestern Ontario due to the large number of small rural centres and long transit times required to reach Emergency Departments.

While these technologies are interesting in isolation, their implementation would be most beneficial in the context of an integrated approach through an electronic medical record. These technologies could be easily implemented in our health care system; however, without a comprehensive electronic medical record system their efficacy is not as great. We need strong physician leadership and political leadership to implement these technologies and revolutionize the delivery of emergency medical care and improve patient management.

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An interview with Dr. Shiva Kalidindi

Joyce Zhang (Meds 2015), Lauren Sham (Meds 2014), Abdul Naeem (Meds 2014)

She was a 14 year old girl, previously healthy, who suddenly collapsed while she was running. When she was brought into the pediatric emergency department, she was waning in and out of consciousness. They resuscitated her, got fluids going, but it was still unclear why she was fading in and out. Prolonged resuscitations are challenging, but this one was particularly so because the etiology of her cardiovascular collapse was unclear. This went on for some time. Four hours later, while she was being transported to the ICU, she was pronounced dead. In the end, the cause of her myocardial infarction was found upon autopsy: an anomalous coronary artery. Usually these patients would present dead to the ER. But this time, she died in spite of their best interventions.

According to Dr. Shiva Kalidindi, the most challenging part of being an emergency physician is when the outcome has not gone the way that you would like. When he has thought back to this patient, he has wondered, “Did I do the right thing at the right time?” Medically, there are always questions. But he knows that they did all that they could do for this patient. He takes it as a good lesson for him to improve on his interaction with the team, as well as an opportunity to do better with integrating the family into resuscitation care, keeping them involved and constantly updated. This helps them in knowing that everything that can be done for their child is being done.

Dr. Kalidindi is a Pediatric Emergency Physician at Victoria Hospital and Associate Director of the International and Elective Program in the Global Health Office at the Schulich School of Medicine and Dentistry. He attended medical school at Bangalore Medical College in India and subsequently completed his Masters in Public Health at the University of Albany. He completed his residency and fellowship training in Pediatric Emergency Medicine at the Children’s Hospital of Michigan. He then moved to Canada to practice about four years ago.

Choosing pediatrics was an easy decision, as this was his passion during medical school. However, it was not until his rotation in emergency medicine during his residency that he discovered that his professional niche lied at the interface of pediatrics and emergency medicine. For him, the beauty and fascination of emergency medicine is the challenge of coming up with a diagnosis and then managing or at least stabilizing the patient until further care is available. He loves working with children in the emergency setting in particular because children are relatively resilient to illnesses and they are able to recover quickly. “Even the sickest of kids – you walk up to them and say “How are you?” and they say “I’m fine!” with a smile.”

As society becomes more culturally diverse, physicians need to be experienced in cultural competency. This requires one to keep an open mind, trying to understand the family’s values and beliefs, while balancing those with our desired clinical approaches and outcomes. It becomes

particularly important when caring for a child – they usually come with parents, if not even more family members. “As long as you can set up that common ground: the parents want their child to get better, the child wants to go out and play, and physicians want to see their patients get better, it becomes easier to take care of them. It’s a joy.” Especially in pediatrics when it can be impossible to get a history from a child, it can really boil down to the parent’s understanding of the child’s illness.

Understanding cultural practices is one of the purposes of the Global Health office. In Dr. Kalidindi’s opinion, global health experiences makes one a better physician especially when catering to a diverse population. “When you see medicine being practiced in a challenging environment, or a resource-restricted environment, it provides you a valuable perspective. We do not realize what we have here [in Canada], until you see how it is in other places.” Most importantly, he wants to make international electives a meaningful experience for students. “Having an experience is one thing, but being able to reflect on it and learn from it is another thing.” It is about being an observer as well as a contributor, and not a barrier. He says that in order to have a meaningful contribution, one must have a dialogue with the community – see as to what their needs are and how we can potentially address those needs. This can only happen if there is sustainability to the ongoing collaboration. “What we see as beneficial to a local community may not actually be beneficial.”

Being in such a demanding specialty, Dr. Kalidindi advises that the key is to achieve work-life balance. For him, it all comes down to the ability of switching off work when work is done. Emergency medicine gives him the luxury of being as diligent as he can be while at work, and conversely the ability to put away his pager when the shift is finished. “Even in the most difficult of circumstances where I’ve had a challenging patient, which may or may not have gone well, I’m able to go back home and spend quality time with my kids and my wife.” He succinctly states the advantage of working in the emergency department: “Do an eight hour shift. Do the best you can. When you’re done, you’re done.”

It is clear that Dr. Kalidindi loves what he does. “The thing with pediatric emergency is that you have a lot of gratifying moments. It’s easy gratification. A patient might come in with a radial head subluxation, a nursemaid’s elbow. You just walk up to the patient and do a gentle twist. I mean, the parents think the hand is broken or something and you’re able to fix it! Suddenly the kid is moving their hand and the parents think you’re a miracle maker – it’s beautiful that way.” Despite all the challenges, it’s clear that pediatric emergency is where he belongs. “We are the first to hand out popsicles and stickers in peds emerg. It’s a joy to see a child smile!” It definitely sounds like a rewarding place to be.

Responding to an emergency – how stress affects medical trainees

Kim Fielding (Meds 2014), Roman Shapiro (Meds 2014) and Elaine Tang (Meds 2015)

Faculty Reviewer: Dr. Lois Champion, M.D., FRCPC (Department of Anesthesia/ICU)

Whether arriving as a first responder to the scene of a motor vehicle accident or attempting to resuscitate a patient in the emergency room, medical trainees who find themselves in an emergency situation have to think quickly on their feet. The physiologic stress response that occurs during such an event is influenced by many factors. Most importantly, the individual must assess whether they have the resources needed to solve the problem. These include intellectual, social, material and emotional resources. If the individual perceives that they have the necessary resources, the situation is defined as a challenge. On the other hand, if the individual does not feel that they are adequately equipped to handle the situation, they will experience distress.¹

In any stressful event, the classic “fight-or-flight” response, described by Walter Cannon in the 1930s, is achieved by activating the sympathetic nervous system.¹ The release of epinephrine and norepinephrine, in a matter of seconds, results in characteristic increases in heart rate and respiratory rate, as well as diaphoresis and increased blood pressure. In addition, the individual may experience feelings of anxiety. Hans Selye, also in the 1930s, divided this response into stages: the alarm phase, in which the individual identifies the stressor and activates the sympathetic nervous system, the resistance phase, in which the body attempts to cope with the stressor, and the exhaustion phase, in which the body is unable to continue to function normally.²

Another dimension of the stress response is the activation of the hypothalamic-pituitary-adrenal axis and the subsequent release of cortisol into the bloodstream. This response takes longer to initiate, occurring within 5-40 minutes after the stressor is identified. The result of the increased cortisol level is an increase in blood glucose as well as variable effects on the brain, specifically in the amygdala, hippocampus and prefrontal cortex.¹ The amygdala is an area of the brain thought to be most closely associated with fear, while the hippocampus has been demonstrated as a necessary component in activities relating to memory. The prefrontal cortex drives executive functions, such as attention and decision-making.

A large amount of research has been done evaluating the impact of stress on an individual’s cognitive abilities. Though the results seem to be conflicting, there are some common patterns that have been described. Studies have shown that an individual’s selective attention to a stressor may be enhanced, allowing them to block out other seemingly irrelevant information. If the stressor is the situation at hand, as in a need to stop bleeding in a car accident victim, then this can be viewed as beneficial. On the contrary, if the situation at hand is intubating a patient, but the stressor is the attending physician who is judging one’s performance, then the attention will be geared toward the physician and not the task at hand, which could be detrimental.² Other researchers have shown that tasks requiring divided attention, as in managing multiple trauma victims, are impaired due to the stress response.³ One proposed

mechanism for this impairment is the over activation of protein kinase C by norepinephrine in the prefrontal cortex.⁴ Stress may lead medical trainees to experience “tunnel vision” or “premature closure” in which they do not consider all possible diagnoses in an emergency situation.²

Another area of cognition affected by stress is memory. Many experiments have demonstrated that stress impairs working memory, possibly due to the dopamine efflux caused by cortisol in the prefrontal cortex.⁵ The ability of a medical trainee to remember a variety of information for even a short period of time could be drastically impaired if the individual is in distress. Similarly, memory retrieval is significantly impaired during stressful situations, a phenomenon linked with cortisol’s effect on beta-2-adrenergic receptors in the hippocampus and the consequent decrease in cAMP.⁶ This impairment is most notable during free recall, as compared to recognition memory. There is some benefit of stress on memory, nonetheless, and this is in memory consolidation. Stress has been shown to improve memory consolidation of events specifically linked with the stressor.² It is important to appreciate, however, that it is the stressor and not necessarily the task at hand that will be encoded to long-term memory.

Stress can also impact an individual’s decision-making process, with research showing an increase in hyper-vigilant decision-making during stressful situations.² This is defined as impulsive, disorganized decision-making, with increased use of heuristics, which are experience-based techniques for problem solving, learning and discovery. While this may be acceptable for an experienced physician with many well-developed heuristics, it may not be beneficial to a medical trainee who is just beginning to form such cognitive tools. One study involving medical radiography trainees found a decrease in diagnostic accuracy associated with increased anxiety levels.⁷

It is appreciated that each individual responds to stressful situations a little differently and that unique situations may activate different neural and hormonal pathways within the same individual. Three important factors may influence a medical trainee’s response to stress. The first is the individual’s coping style, be it problem-focused, emotion-focused or avoidance coping. The second is the individual’s perceived control of the situation and whether or not there is thought to be an internal or external locus of control. Finally, the social support of the individual could affect the stress response, with increased social support being associated with decreased cortisol levels.²

The following scenario is a real example, experienced by one of the authors, and illustrates a situation in which a medical trainee may experience significant stress.

While doing an observership in a pediatric emergency room, I was informed by the doctor that there was a trauma case being brought in by ambulance. Suddenly, I felt much more awake and the entire emer-

THINKING ON YOUR FEET

gency room seemed more alive. The paramedics wheeled in a boy on a stretcher, unconscious with normal responses to pain, but not much else. His mouth and nose were covered with blood, so a nurse passed me a gown, gloves and a face mask, explaining, "We don't know what or if he has anything. It's always better to be on the cautious side." As I assisted the nurse in removing the boy's shoes and clothing and checking for I.D., I observed the doctor and other nurses assess the fundamentals of medicine: ABC – airway, breathing, and circulation.

The patient's periphery was cool to the touch, so they brought in warm blankets and covered him from head to toe. His blood pressure was taken immediately by one member of the team, while someone else checked for his pulse. The doctor cleared the airway, checked the nasal passage to ensure there wasn't a blockage and then assessed for breathing. The head nurse stood to one side, going systematically through all the vitals, asking questions as different team members yelled back their responses.

When it was recognized that the ABCs were stable, a visible tension left the room as the secondary assessment continued. The patient had to be moved from the spinal board to the stretcher and I was called in to assist with supporting the patient, while the physician checked for any visible or palpable trauma. Next, a urine tox-screen was needed, so I was told to hold down the patient while they inserted a catheter. As the catheter was being put in, the patient began to fight against the pain and four people worked actively to try and hold the patient down. Finally, the catheter was in, the urine sample taken, and the catheter removed. It was time to try and wake the patient up.

In my discussion with the physician after the episode, I learned a lot of things. I realized that no one was idle in the procedure room; everyone worked together as a team to help stabilize the patient. As a first year medical student, the experience, while exhilarating, also demonstrated to me the necessity of focus required during emergency situations. There isn't always time to take a step back and consider all your options. Your instincts direct you towards the vitals and as you assess those, you use key markers along the way to indicate the next step. Though the physician was tense during the episode, stress did not seem to impair the actions of my preceptor. I, on the other hand, felt frozen to the spot at times and only moved when instructed to.

Ultimately, the impact of stress on one's ability to think on their feet should not be underestimated. Medical trainees who are in distress will experience cognitive changes that affect their attention, memory, decision-making and more. The positive outlook is that, with experience, stress levels should decrease and, in emergency situations, one will be better able to think quickly on their feet.

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A case of an anomalous origin of left main coronary artery from right sinus of valsalva leading to sudden death

Yikang Lin (Meds 2014), Stephen Cornish (Meds 2015)

Faculty Reviewer: Dr. Rod Lim MD (Paediatric Emergency Department)

We spend the bulk of our efforts attempting to understand the basic framework of medicine and the top 5-10 entries on differential lists. And for good reason – these are the things that we will assuredly see and have to treat. There are always, however, going to be cases that fall outside of the realm of the usual. These cases puzzle the best amongst our profession and make us wonder if there was anything we could have done differently.

A young adolescent female presented to a pediatric emergency department with chest pain, shortness of breath, and cyanosis. She had been jogging when the chest pain started, and then collapsed. Except for a previous possible seizure or syncopal episode a few years earlier, she was otherwise healthy. Initial vital signs were a heart rate of 58 bpm, blood pressure of 70/40 mmHg, respiratory rate of 50 breaths/min, temperature of 37°C, and oxygen saturation of 68% on room air. An electrocardiogram displayed ST changes suggestive of ischemia.¹

The initial presentation suggests that she was in shock – a pathophysiologic state of inadequate tissue perfusion and subsequent hypoxia.² It is subcategorized by the underlying mechanisms: reduced blood volume (“hypovolemic shock”), a pathological distribution of blood volume (“distributive shock”), and/or failure of the pump (“cardiogenic pump”).³ If corrected quickly, the short-term effects of poor perfusion are generally reversible.² Prolonged shock, however, will eventually lead to irreversible damage including cell death, end-organ damage/failure, and death.²

Typically, pediatric patients presenting with shock in the emergency department are experiencing hypovolemic shock due to dehydration (resulting from diarrhea or osmotic diuresis) or trauma (and subsequent hemorrhage), or distributive shock from sepsis.³ The routine work-up for such a patient is to identify and address any life-threatening conditions (via a rapid assessment of the patient’s general appearance, breathing quality and rate, and circulation to skin), recognize circulatory compromise, and then identify the type of shock and find the underlying cause.⁴ The detective work involved with this last step includes a detailed history and physical exam, combined with the necessary ancillary tests.³

Our patient’s history and physical findings suggested a cardiogenic cause of shock. One of the more alarming aspects of her presentation was her low blood pressure and heart rate. In pediatric populations, a low blood pressure indicates a later and more severe stage of shock.² Clinically, shock has been described in three progressive stages.³ The first stage is compensated shock, in which the body’s homeostatic mechanisms (increased heart rate and peripheral vasoconstriction) are able to maintain adequate perfusion and systolic blood pressure.² If left untreated, compensated shock progresses to hypotensive shock, in which the compensatory mechanisms are overwhelmed and there is a subsequent drop in systolic blood pressure along with signs of poor perfusion (e.g.

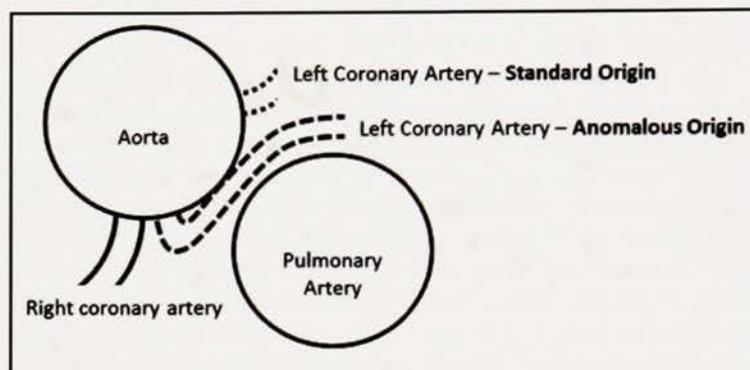


Figure 1: Standard vs. Anomalous Origin of Coronary vessels (adapted from reference 11)

altered mental status).² If the inadequate organ perfusion continues, a patient will eventually progress to irreversible shock, in which end organs are irreparably damaged, and despite resuscitation, the patient will die.²

To prevent the progression through these stages of shock, current guidelines advise an aggressive, multi-pronged treatment algorithm aimed at improving perfusion and end organ function.⁴ The first arm is rapid fluid resuscitation using isotonic crystalloid solution.⁴ Early vascular access is needed to facilitate fluid resuscitation efforts. Another treatment arm is airway and respiratory support in the form of supplemental oxygen, positive pressure ventilation, and/or intubation.⁴ Monitoring of physiological indicators (including blood pressure, quality of pulses, skin perfusion, mental status, and renal output) before and after interventions provide additional clues to the type and underlying causes of shock.³ This information would direct the final arm of treatment, the selection of appropriate medications.⁴

Our patient exhausted the available treatment modalities. She was started with peripheral venous lines.¹ Gravity alone was not enough to push the requisite amount of fluid.⁵ Direct pressure on the bag and “push-pull” method were employed to maximize fluid delivery. Additional vascular lines were established using bilateral intraosseous (IO) infusions into her proximal tibias.¹ These infusions take advantage of the veins that drain the medullary sinus of long bones.⁵ Due to their support from the bony-matrix, these veins do not collapse. After cannulation to gain access to the medullary sinus using a large bore needle and drill, and flushing with normal saline, an IO has equivalent infusion rates to a 21 gauge peripheral intravenous catheter.⁵ She was placed on supplemental oxygen, intubated, and given inotropic medications (dopamine at 5-20mcg/kg/min, norepinephrine at 0.05-0.5mcg/kg/min, and epinephrine at 0.1-3.0 mcg/kg/min).¹ Her cardiac output deteriorated, and eventually resuscitation attempts were discontinued.¹

The post-mortem examination of the heart revealed an anomalous origin of the left main coronary artery (LMCA) from the right sinus of

ZEBRA FILES

Valsalva.¹ The precipitating cause of death for our patient was determined to be acute myocardial ischemia. The standard shock management regimen was not sufficient to treat her condition, and parts of the administered therapy may have been detrimental.

Under normal circumstances, there are two sinuses of Valsalva arising from the aorta distal to the aortic valve. Anomalous origin of coronary arteries (AOCA) is a rare (estimated 0.1-0.3% prevalence)⁶ congenital heart defect,⁷ in which coronary vessel(s) follow an abnormal route (see Figure 1). Our patient's left main coronary artery arose from the right sinus, passed between the pulmonary trunk and ascending aorta, before supplying its dependent heart tissue. Despite its low prevalence, AOCA is the second leading cause of sudden death in young athletes, representing approximately 10% of deaths in this population.⁶ This discrepancy may be due to a high mortality rate associated with this condition and/or the under diagnosis of this condition (affected individuals are typically asymptomatic during daily activities of living).

AOCA is often included in the differential for sudden cardiac deaths in young – albeit as a diagnosis of exclusion. Even so, when the condition actually causes a coronary event due to the insufficient oxygen delivery when placed under stress, its presentation is very difficult to discern from other conditions that cause similar symptoms.⁸ Most cases are identified upon autopsy, where myocardial fibrosis in the chronically under-perfused heart tissue and signs of hyper-acute myocardial infarction may be evident. In our case, the young girl was given inotropic agents in order to increase her cardiac output by increasing force of ventricular contraction.¹ However, unbeknownst to the physicians, these agents further enlarged her pulmonary trunk and aorta upon each heartbeat, further occluding her LMCA, and thus exacerbating the ischemia of the heart muscle.

A case like our patient's will always beg the question, what could have been done differently? The reality of this case is that AOCA is incredibly difficult to identify, especially in the emergency setting.⁹ However, there is always something that can be gained from evaluating any and all aspects of the case in order to gain wisdom and knowledge to aid us in future patient care. In this case, there were a few clues. The first clue was her history. From the literature, the myocardial infarction in individuals with AOCA is often preceded by a period of strenuous exercise.⁷ Our patient was in her teens, otherwise healthy, and had been jogging before experiencing non-specific chest pain, followed by collapse and loss of consciousness. Exertional syncope is always more concerning than non-exertional. In conjunction with her response to treatment, this presentation may have raised suspicion of a myriad of cardiac conditions, including AOCA. More importantly, on further questioning, the initial presentation had been precipitated by exertion. She had fully recovered from that incident, but if she had been sent for further evaluation it is possible that the defect may have been detected before she had a second syncopal episode, and may have been surgically corrected.

Heart function tests including the ECGs and ejection fractions that were done for our patient have not been demonstrated to be helpful diagnostic tools for coronary artery anomalies.¹⁰ Imaging, however, allows physicians to note the presence of a congenital defect in the origin of the coronary, follow the artery's unusual course, and assess the integrity of the artery by looking for regions of stenosis. One of the best methods to identify this anomaly is the use of computed tomographic angiography (CTA) to visualize the displaced coronary artery. This type of imaging is unfortunately not practical in such an emergency setting. Transthoracic and transesophageal echocardiography have also been demonstrated to be feasible and practical in young patients, and these imaging modalities can be used to justify ordering a CTA scan.¹⁰ Our patient did get an emergent echocardiogram during active resuscitation, but the vessels

were not clearly visualized.¹

Upon identification of the anomaly, treatment is possible through surgical means. Coronary artery bypass grafting (CABG) remains the standard treatment in these instances, with some surgical teams electing to also 'un-roof' the associated anomalous coronary artery.⁵ This technique involves modifying the ostium of the coronary artery by excising ('un-roofing') the common wall between the aorta and anomalous artery. Attempts to re-implant the anomalous vessel into the correct aortic sinus have been completed, but are technically challenging and are not yet indicated over the safer surgical alternatives. Our patient was never stable enough to consider this option.

The medical profession is ripe with challenges for practicing physicians. One of the most mentally difficult tasks required of physicians is the need to maintain an expert knowledge of countless medical conditions, many of which are exceedingly uncommon epidemiologically. Losing a patient who could have been helped by the correct treatment if the proverbial "zebras" had been recognized in time is a true test of a physician's confidence, and is a stark reminder that the science and art of medicine demands perfection from imperfect people.

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Larrey's Revolution

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July 14, 1789. "To arms!" echoed throughout Paris. The city was in a state of unrest and angry mobs roamed the streets. Spurred on by discontent with the monarchy and nobility, Parisians were seeking to gather large quantities of arms and ammunition. This ultimately culminated in the storming of the Bastille, an imposing fortress and a symbol of monarchical oppression. Its capture galvanized revolutionaries and helped justify their cause. The French Revolution was beginning.

The French Revolution and the following Napoleonic era transformed the social and political structure of Europe. In three years, France's long-standing monarchy was abolished. The aristocracy and clergy were stripped of authority as class distinctions were eliminated and democracy was established. Ideas of liberty, equality, and citizenship prevailed. The Revolution also marked the beginning of over two decades of war that consumed Europe. Revolutionary ideals resonated with people beyond France and well after the end of the Napoleonic Wars. This period of change and turmoil affected all aspects of human life worldwide, and medicine was no exception.

Indeed, the medical profession contributed to the Revolution and was forever changed by it. For Dominique Jean Larrey (1766–1842), the storming of the Bastille was a defining moment. On July 14, 1789, he led a contingent of 1500 medical students:

I put myself at the head of these young men... and we were the first to march against the tyrants... Everyone armed himself as best as he could and we marched through the night inciting the populace to rebellion. On the morning of the fourteenth we armed ourselves at the Invalides and turned our steps towards the Bastille. If we did not have the honour of mounting the first assault, it was only because the immense crowd before the gates prevented us, and not because we lacked either the enthusiasm or the courage.¹

Larrey would soon become a surgeon in the army of the French revolutionary government and later, surgeon-in-chief to Napoleon Bonaparte's Imperial Guard. He strongly believed in the values of the Revolution and was an idealist.^{1,2} While these characteristics created challenges in his military career, they fuelled his determination to provide compassionate and humanitarian care for the wounded. Today, he is considered the father of emergency medicine. Social revolution and years of war created the circumstances necessary for Larrey to implement and develop an unprecedented medical system.

PRE-REVOLUTION

Before the French Revolution, medical care was largely absent for wounded soldiers. Military operations and manoeuvres had absolute priority and military commanders believed the wounded simply interfered with their battle plans.^{1,3} Physicians and surgeons seldom belonged in

armies and responsibility for care fell to fellow soldiers, local inhabitants, and camp-followers.¹ Wagons were used to remove the wounded after a battle ended, but were required to wait four kilometres behind the army and never arrived in less than twenty-four to thirty-six hours.^{4,5} Regulations denied immediate treatment and evacuation,¹ and soldiers often died waiting. Compounding the problem was the status of medical officers employed to oversee collection of the wounded. The officers were often surgeons, poorly paid, and did not have military rank or authority.^{1,2,6} Surgeons overall belonged to the barber class, were seen as inferior to physicians, and lacked social and political power.⁷

REVOLUTION

The French Revolution had important social implications for surgeons. Traditionally trained through apprenticeships and removed from positions of privilege, they opposed the monarchy and its institutions. Revolutionary France saw a reorganization of universities and medical education, with surgeons at the forefront, emphasizing practical learning.⁷ Nonetheless, their newfound prominence in education and civilian life was not readily applied to the battlefield. For military medicine, it was a case of *plus ça change, plus c'est la même chose*.¹

Meanwhile, warfare at the beginning of the Revolution was becoming increasingly violent. Casualties were produced on a large scale as a result of military conscription, massive troop formations, and the use of concentrated artillery and accurate musketry.^{8,9} Furthermore, the rise of Napoleon ushered in a disregard for military conventions dictating the conclusion of battles and procedures for surrender. Instead, armies were to be annihilated. The conditions of war created a greater need for medicine to be present, but without a change in the culture of military medicine, the wounded would continue to be overlooked. Military medicine required an individual to take initiative and challenge military authority.

Dominique Jean Larrey was moved by the unnecessary deaths he witnessed on the battlefield in 1792^{1,5} and resolved to change the military mindset. He once reflected that "the misfortune of others affect me strongly. Serious disasters afflict my soul and plunge me into the deepest grief; I often think I can do something to help, and even attempt to remedy the situation."² Fortunately, his conviction, driven by Revolutionary ideals, was aided by the Revolution itself. The Reign of Terror was underway and stipulated that anyone caught opposing the Revolution would be sentenced to death. It enforced Revolutionary values, of which equality for all citizens was paramount. Military generals were compelled to accept Larrey's proposals and give him permission and authority to implement his ideas.¹

INNOVATION

Larrey wanted to deliver prompt treatment and evacuation to casualties on the battlefield. He recognized that delaying treatment complicated

HISTORY OF MEDICINE

patient cases, and lead to hemorrhage, increased pain, infection, and death.⁸ In particular, he went against the predominant practice of waiting as long as twenty days to amputate and advocated for surgery within the first few hours after injury.^{2,3,10} Inspired by the quickness and mobility of flying artillery, cannons attached to horse-drawn carriages, Larrey created the *ambulances volantes*, or flying ambulances.

The concept of flying ambulances was first tested in 1793¹⁰ and approved in 1794.⁵ There would be two types. A two-wheel model could carry two soldiers and was suited for use on flat terrain, while a four-wheel model could carry four lying casualties and travel across mountains.^{4,5} In addition to providing transport, they were equipped for on-the-spot surgery and medical treatment.¹¹ The flying ambulances became the core of Larrey's system of medical care.

Each ambulance unit consisted of a surgeon-in-chief and three divisions of 113 people and 12 flying ambulances.^{4,10} Larrey was careful to include military officers and soldiers in his ambulance teams, since medical officers alone did not have any authority on the battlefield.¹ Whether the situation demanded immediate treatment or evacuation, the ambulances would eventually converge at dressing stations or hospitals set up at the rear.

Unfortunately, due to political opposition to Larrey's plans, his system did not debut until 1797 in the presence of Napoleon Bonaparte. Napoleon was impressed and praised Larrey: "Your work is one of the greatest conceptions of our age. It alone will suffice to ensure your reputation."¹ The future French emperor's admiration and support of Larrey's work helped the flying ambulance system achieve success. The presence of flying ambulances in the military boosted the morale and confidence of French soldiers.¹⁰ Unsurprisingly, they adored Larrey and called him "The Saviour."^{4,10}

The implementation of flying ambulances was accompanied with the conception and development of systems of triage. The multitude of casualties, the range of injury severities, and limited resources created a necessity for the sorting of patients.⁵ First and foremost, Larrey explicitly instructed his medical officers to "always start with the most dangerously injured, without regard to rank or distinction."¹ This applied to both treatment and evacuation. Larrey was also known for providing the same quality of care to enemy wounded.^{3,6,12} On resource management and military rank, Larrey noted, "The slightly wounded can go to the hospital in the first and second line, especially officers because the officers have horses."¹⁰ With triage, Larrey created a complete, efficient, and organized medical system for those wounded in battle when there was none to begin with.

EMERGENCY MEDICINE

Larrey's unprecedented medical system was established through his determination, and through the circumstances created by the French Revolution and its subsequent wars. His flying ambulances are precursors to the modern ambulance. The basic concepts of triage have remained unchanged¹³ and are integral to modern emergency rooms, disaster management, and military medicine. His system reflected the fundamental principles of emergency medicine by providing immediate response, transport to care stations, care en route, and medical and surgical treatment. Dominique Jean Larrey introduced emergency medicine to the world and, with it, revolutionized the way warfare was perceived. The wounded were no longer ignored and humanity prevailed despite the inhumanities of war.

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