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SURGERY IN LOW AND MIDDLE INCOME COUNTRIES

The Successful Implementation of a Trauma and Acute Care Surgery Model in Ecuador

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Abstract

Background For years, surgical emergencies in Ecuador were managed on a case-by-case basis without significant standardization. To address these issues, the Regional Hospital Vicente Corral Moscoso adapted and implemented a model of "trauma and acute care surgery" (TACS) to the reality of Cuenca, Ecuador.

Methods A cohort study was carried out, comparing patients exposed to the traditional model and patients exposed to the TACS model. Variables assessed included number of surgical patients attended to in the emergency department, number of surgical interventions, number of surgeries performed per surgeon, surgical wait time, length of stay and in-hospital mortality.

Results The total number of surgical interventions increased (3919.6–5745.8, $p \leq 0.05$); by extension, the total number of surgeries performed per surgeon also increased (5.37–223.68, $p \leq 0.05$). We observed a statistically significant decrease in surgical wait time (10.6–3.2 h for emergency general surgery, 6.3–1.6 h for trauma, $p \leq 0.05$). Length of stay decreased in trauma patients (9–6 days, $p \leq 0.05$). Higher mortality was found in the traditional model ($p \leq 0.05$) compared to the TACS model.

Conclusions The implementation of TACS model in a resource-restrained hospital in Latin America had a positive impact by decreasing surgical waiting time in trauma and emergency surgery patients and length of stay in trauma patients. We also noted a statistically significant decrease in mortality. Savings to the overall system and patients can be inferred by decreased mortality, length of stay and surgical wait times. To our knowledge, this is the first implementation of a TACS model described in Latin America.

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Introduction

Ecuador has a population of approximately 17 million people, with a health system organized into nine geographical zones; each zone has one primary public hospital. Hospital Vicente Corral Moscoso (HVCM) is a public hospital with 260 beds located in southern Ecuador (zone six). The HVCM is considered to be a referral center in the south of the country. This hospital has a catchment area comprising two major zones (zones six and seven), which includes six total provinces and over 2 million inhabitants (Fig. 1) [1].

Prior to 2012, surgical emergency care at the HVCM was not protocolized. In the absence of a service dedicated to trauma and surgical emergencies, a total of seven general surgeons attended to these patients in between or after scheduled elective cases. Under this traditional model, attending general surgeons worked between 4 and 6 h daily at the public hospital, after which they would be available by phone from their secondary positions. These secondary jobs, which usually are busy private clinics starting in the afternoon and lasting into the evening, are very common in Latin America. These positions often represent the main source of income required to supplement the commonly low salaries offered within the public system.

In the traditional model, patients were routinely subjected to long wait times and acute care pathology was often advanced by the time the patient arrived in the operating room. Regardless of pathology, patients with acute surgical problems waited for surgical intervention until a general surgeon had completed his or her daily elective cases, and there was an available operating room. Prior to the implementation of the trauma and acute care surgery (TACS) model, there was not an operating room dedicated to the care of these patients, and typically, surgical cases were not permitted to use an operating room until after 4 pm. The interns and residents were the only constant presence providing emergency care, as the

Fig. 1 This map depicts the providences of Ecuador that are served by the HVCM. The providences in red indicate zone 6, while those in blue indicate zone 7. The HVCM is located in zone 6 in the providence of Azuay

attending surgeon was only in the hospital for 4–6 h each day. The care under the surgical trainees resulted in high variability in clinical and surgical decision making. Learning was dissimilar across trainees as it resulted from primarily experience-based rather than evidence-based care. The previous system of care could not secure patient care continuity at the attending level among several other deficiencies [2]. Overall, the traditional model yielded a disjointed approach to surgical disease management for the trainees and more importantly an irregular delivery of surgical care to the patients. With this reality in mind, the question was asked: Can a new context be designed to implement a system aimed at delivering high-quality, efficient and cost-effective care tailored to the local needs within HVCM [1]?

Our team was awarded a $2 million grant from the Ecuadorian Ministry of Public Health in order to change the paradigm of trauma and emergency surgery care in southern Ecuador and to serve as a pilot program for the rest of the country [1]. With this support, the first TACS model in this region became operational on November 1, 2012. The TACS model was created with the objective of implementing a single surgical service exclusively dedicated to caring for trauma, emergency general surgery and surgical critical care patients. While inspired by the North American model of TACS [3], it was strictly adapted to the realities of this region of Ecuador.

For the complete implementation of the TACS model, a transition period of 3–6 months was required. During this time, the surgical team was assembled. This team initially consisted of four surgeons dedicated to the trauma and emergency patients. As resources were obtained, more surgeons were hired over the following 6 months until a full complement of seven surgeons dedicated only to trauma and emergency surgery was achieved, ensuring the presence of an in-house attending surgeon 24 h per day, 7 days per week. Four of the surgeons previously caring for emergencies under the traditional model began to only manage elective cases. Two additional anesthesiologists were also hired to ensure day-and-night availability to the TACS service. Additionally, with the aforementioned monetary support, an area within the hospital was constructed specifically for the care of critical surgical patients requiring immediate and aggressive resuscitation. This included a triage area, an area for resuscitation of critical patients, an observation unit, a dedicated space to perform procedures and a six-bed trauma unit. Importantly, the trauma unit had the availability of personnel and resources for the care of critically ill patients not previously available at the HVCM [1]. An operating room dedicated only to the management of trauma and emergency surgery patients was reserved, for which an additional anesthesia machine and laparoscopic tower were purchased. Ancillary services including the blood bank, laboratory and radiology were augmented to be able to meet the needs of the new service. In all, these changes transformed the hospital into a tertiary care center and a major referral center for the southern part of the country, with the ability to attend to patients 24/7/365.

As part of the development of the TACS model, an organization of medical students across the three major medical schools in the region, known as the "League of Trauma and Emergencies," was developed. This organization emulated that originally suggested by the University of Campinas in Brazil in the 1990s [4]. Founded in 2013, the main role of the League of Trauma and Emergencies is to educate the community through workshops pertaining to topics such as pedestrian safety, blood donation, appropriate use of 9-1-1, first aid, basic life support (BLS) and the basics of trauma [5]. The league not only plays a major role in community outreach fundamental to support an effective trauma system but it also promotes in its members the knowledge of the initial management of trauma and emergencies and offers the opportunity to participate in supervised patient care within the emergency room, operating room and trauma center early in their training [1].

The objective of this study is to measure the effects on patient care and workflow after the implementation of a TACS model designed and carefully adapted to the region of Cuenca, Ecuador, and to compare several aspects of emergency surgical care provided before and after such implementation.

Materials and methods

A cohort study was completed between 2008 and 2017. The study included two groups. The first group was the "traditional model" that comprised patients managed prior to the creation of the TACS service, between 2008 and 2012. The second group included patients managed after the creation of the TACS service between 2013 and 2017. In the traditional model, traumas and surgical emergencies were attended to by general surgeons in between or after elective surgical practices. In this model, attending surgeons were in the hospital for, on average, 4–6 h per day and were only available to the residents who were on call in the hospital by phone from their secondary positions after they left the hospital. The acute care surgery model involved the presence of an in-house attending surgeon 24 h per day, 7 days per week, wherein that surgeon was responsible for emergency general surgery, trauma surgery and surgical intensive care.

Primary endpoints included number of surgical patients attended to in the emergency department, number of surgical interventions in the operating room, number of

surgeries performed per surgeon, surgical wait times measured from presentation to the emergency department to arrival in the operating room, length of stay and in-hospital mortality.

Prior authorization of the hospital administration allowed for data collection from the medical records department of HVCM. Subsequently, a database was created. Statistical analysis was undergone with SPSS v 22, Epidat 3.1, Microsoft Excel® 2016. Relative risk was used to compare dependent variables. For comparison of means, the Kolmogorov–Smirnov test and the homoscedasticity tests were used. The Student's *T* test or the Mann–Whitney test were used for the comparison of independent variables, according to the distribution of each variable. Statistical significance was determined by a p value ≤ 0.05.

Results

The total number of patients presenting to the emergency department with a surgical problem as defined by the triage physician at our institution increased with the rate of population increase. In the comparison of the means, it was observed that under the traditional model, an annual average of 14,888.60 SD $\pm$ 2148.36 surgical patients were evaluated and managed yearly in the emergency department versus an average of 16284.60 SD $\pm$ 27,775.76 yearly in the TACS model ($p = 0.4$) (Fig. 2).

We also observed a statistically significant increase in the number of surgical procedures performed at our institution when comparing the traditional model and the TACS model, increasing from an average of 3919.6–5745.8 surgical interventions per year ($p \leq 0.05$) (Fig. 3). A total of 19,598 emergency surgeries were performed under the traditional model, of which the breakdown of acute care surgery and trauma patients is not available within the data. A total of 28,729 emergency surgeries were performed after the implantation of the TACS model, of which 22,981 (80%) were acute care surgery patients and 5748 (20%) were trauma patients. Moreover, the number of surgeries performed per surgeon increased in a statistically significant fashion from 85.37 to 223.68 surgeries per surgeon per year ($p \leq 0.05$) (Fig. 4).

We found a statistically significant decrease in operating room wait time in both trauma and emergency general surgery patients. Surgical wait time decreased from 10.6 to 3.2 h for emergency general surgery patients and from 6.3 to 1.6 h for trauma patients ($p \leq 0.05$). We also found a statistically significant decrease in length of stay for trauma patients from 9 to 6 days ($p \leq 0.05$) (Table 1). Length of stay for emergency general surgery patients decreased from 4 to 3 days but was not found to be statistically significant ($p = 0.43$).

There was found to be a greater risk of death for patients cared for under the traditional model with a mortality rate of 1.1% in the traditional model compared to 0.86% in the TACS model ($p \leq 0.05$) (Table 2). One of the quality metrics for hospitals in the region is mortalities before and after 48 h from admission. Deaths within the first 48 h of admission are attributed to the severity of injury or illness, while those that occur after 48 h are attributed to a failure of the system. While there is a trend to less mortality after 48 h in the TACS model, with a mortality of 87.9% in the traditional model and 85.4% in the TACS model, this difference was not statistically significant ($p = 0.55$).

Discussion

Trauma and emergency surgery patients represent a large proportion of surgical disease worldwide, with one third of deaths being due to conditions needing emergency surgical procedures. Ninety percent of deaths due to trauma worldwide occur in LMICs [6]. In Ecuador, traumatic and acute care surgery pathologies continue to occupy the top of the list of the causes of death [7]. Our study confirmed

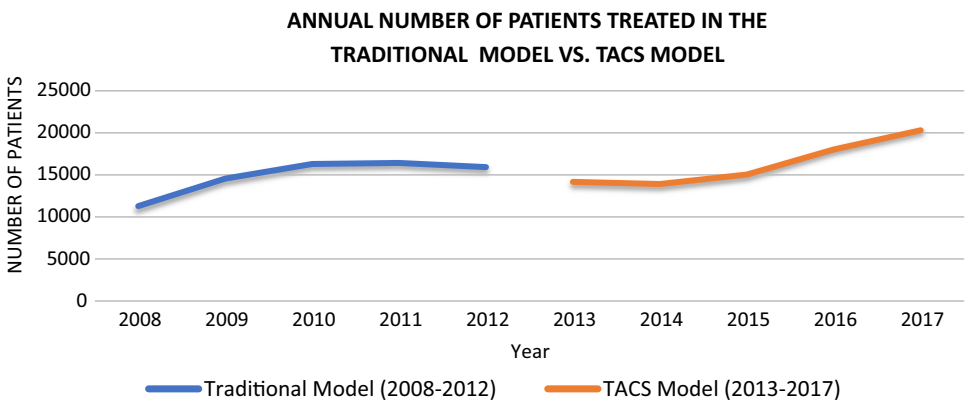

Fig. 2 Comparison of annual number of surgical patients attended to in the emergency department in the traditional model (2008–2012) and the TACS model (2013–2017)

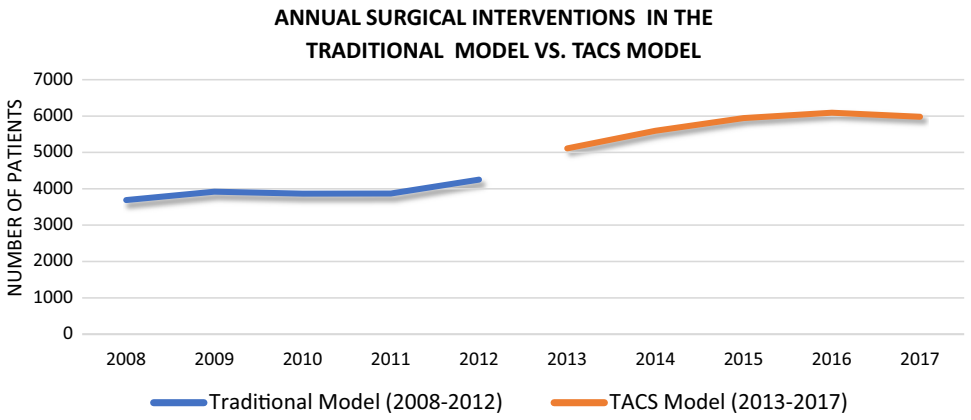

Fig. 3 Comparison of annual number of annual surgical interventions between the traditional model (2008–2012) and the TACS model (2013–2017)

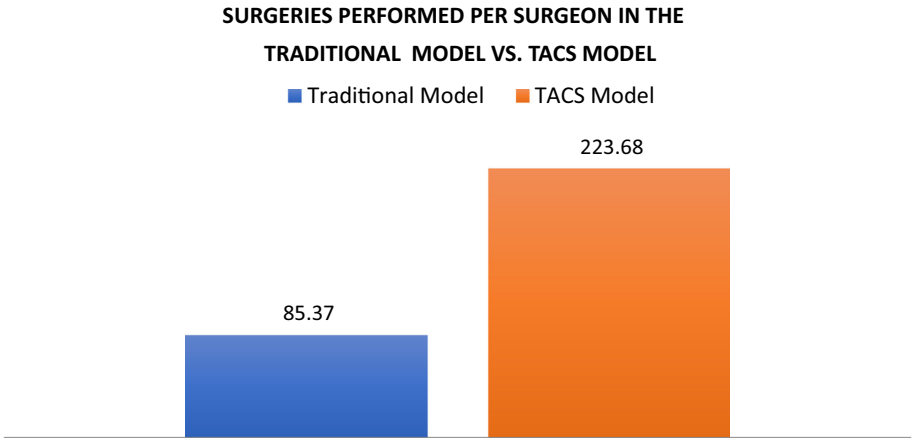

Fig. 4 Comparison of the annual number of surgeries performed per surgeon in the traditional model (2008–2012) and the TACS model (2013–2017)

Table 1 Comparison of mean wait time for the operating room and postoperative length of stay in the traditional model (2008–2012) compared to the TACS model (2013–2017)

Mean wait time for operating room and length of stay			
Variable	Traditional model	TACS model	*p* value
Surgical wait time for emergency general surgery patients	10.6 h	3.2 h	<0.005
Surgical wait time for trauma patients	6.3 h	1.6 h	<0.005
Length of stay for emergency general surgery patients	4 days	3 days	0.43
Length of stay for trauma patients	9 days	6 days	<0.005

preliminary data [8] that the implementation of a TACS model at our institution has had a positive impact in improving emergency in our patient population.

Born out of necessity and innovation, the model of acute care surgery as it is known today within North America evolved over a number of years until it was fully developed from a joint meeting of members of the American College of Surgeons (ACS), American Association for the Surgery of Trauma (AAST), Eastern Association for the Surgery of Trauma (EAST) and Western Trauma Association (WTA) in 2003 [9, 10]. The predominant factors that prompted this change included the loss of elective surgery cases due to the progressive specialization and fragmentation of the field of surgery, the development of minimally invasive technologies, advancements in the fields of interventional radiology and gastroenterology and the increasing prevalence of non-operative trauma management. In response to this reality, many hospitals combined trauma services with

Table 2 Comparison of mortality between the traditional model (2008–2012) and the TACS model (2013–2017)

Comparison of mortality by model					
Model	Total mortality	Percent mortality	RR	CI 95%	*p* value
Traditional	124/11,234	1.1%	1.29	1.01–1.64	<0.005
TACS	144/16,792	0.86%			
Model	Mortality ≥48 h	Mortality ≤48 h	RR	CI 95%	*p* value
Traditional	87.9%	12.1%	1.02	0.93–1.13	0.55
TACS	85.4%	14.6%			

emergency general surgery services to create the model of acute care surgery [11]. Critically ill surgical patients were also traditionally cared for by trauma surgeons, and therefore, the provision of critical care in trauma and surgical ICUs around the country became also a responsibility of the "new" acute care surgeon. Services dedicated to emergency surgical care have been shown to have economic and workflow benefits, in addition to promoting quality control protocols and algorithms [12].

The benefit of a specialized acute care surgery service to patient outcomes is well established in the literature. In 2012, Wanis et al. showed that the implementation of a TACS model significantly decreased surgical wait times and reduced the number of surgeries performed after normal work hours, without reducing the duration of postoperative length of stay [13]. Nagaraja et al. conducted a systematic review that included both the TACS model and the traditional model with 18 studies that met the inclusion criteria, wherein it was concluded that the TACS model supplied a safe surgical environment for the patients and was associated with a reduced rate of complications, length of stay and conversion to open for laparoscopic appendectomies and cholecystectomies [14]. A meta-analysis including 14 studies and 7980 patients demonstrated that acute care surgical teams had shorter delay prior to surgery, postoperative hospital stay and complications in patients presenting with appendicitis [15]. Additional benefits demonstrated in the literature include a reduction in mortality up to 31% in emergency general surgery patients managed by an acute care surgery team compared to a general surgery team [16], as well as an increase in the volume of urgent cases with no effect on elective case volume [17].

Outside of the USA, the TACS model has been adapted to the reality of different countries, also demonstrating an improvement in patient outcomes. Across 13 Canadian centers, this model has been shown to improve access to care, the administration of resources, the quality of care provided, outcomes for patients, surgical education for trainees and lifestyles of surgeons in general [11, 18, 19]. The TACS model has had success in both Australia and New Zealand, with evidence of reduction in hospital length of stay, surgical wait time and after-hours operations with the implementation of an acute surgical unit [20]. Acute care surgical units have also been recently described in Singapore [21] and Spain [10]. However, little is known about the delivery of emergency surgical care within Latin American contexts. Local needs, surgical workforce and diversity of resources within metropolitan hospitals and even more markedly within rural settings have not been fully described and vary among regions within the same country and among LMIC countries themselves.

A cost analysis was unable to be performed within our cohort study as the costs in the traditional model were not available for analyses. We believe that under our model, decreased surgical wait time and length of stay can be extrapolated to represent decreased overall cost to the system. Moreover, a decreased mortality rate and fewer patients having to go outside of the public network to a private clinic can be extrapolated to represent an overall saving for the individual. The effectiveness of this model in cost saving is well described in the literature. A 2012 study from Loma Linda University described a savings of $1024.00 per patient undergoing an appendectomy and $3225.00 per patient undergoing a cholecystectomy [22]. Another study by Michailidou et al. described a $1000 per patient savings in cholecystectomies [23].

In order to be sustainable and successful, the TACS model demands constant dedication on the part of the general surgeons, residents, health-care administrators/professionals and the institutions themselves. In addition to benefits to the patient and hospital, it has been demonstrated that the TACS model also benefits the surgeon, with increased case volumes and diversity [24–28]. It was traditionally assumed that choosing a career that included TACS could negatively affect quality of life outside work and represented diminished quality time with family and leisurely activities. In addition, it is often presumed that treating patients with pathologies associated with such high associated morbidity and mortality is less gratifying [29].

However, when there exists a coordinated and dependable system of care for patients, it permits surgeons, patients and institutions to align their objectives so as to achieve quality care while guaranteeing adequate lifestyle for the professionals [30, 31].

In our experience, the most challenging aspect of the implementation of a TACS model was the execution of a cultural change within the hospital as it transformed into an institution able to care for critically ill patients on a 24 h per day and 7 days per week basis. This involved not only the expansion of ancillary services such as laboratory, radiology and blood banking services, but also coordination with the operating room and other surgeons to allow one operating room to be dedicated solely to the management of TACS patients. Moreover, the change required an adjustment on the part of the staff to caring for increasingly ill and complex patients, as previously many of these patients did not survive long enough to make it to the operating room. Now, the TACS model has shaped the culture of the hospital such that there is support not only from the hospital administration, but also subspecialists including neurosurgeons, orthopedic surgeons, vascular surgeons and plastic surgeons. The HVCM has transformed into an institution where 24/7/365 emergency care across subspecialties is readily available.

Despite some of these logistical difficulties, our study shows that the implementation of an acute care surgery model in a resource-limited setting leads to improved and comprehensive patient care. Moreover, we believe that the population served at our institution is similar to that of other LMICs, specifically those within many regions in Latin America. We believe that these results are generalizable and should be implemented in other institutions throughout Central and South America. At the time of submitting this manuscript, we were not aware of any other TACS models being planned or currently implemented within the Latin American region.

The implementation of this model has been very attractive to public health officials in the region of Cuenca and Ecuador, primarily for the palpable results that yielded for patients in the short, medium and long term with specific and measurable outcomes. These outcomes have translated into a better utilization of hospital resources as well improvement of the reputation of our institution within our community and beyond. A committed and multidisciplinary team, with a common vision, is required such that this model continues to be sustainable. Moreover, the support of hospital administration is quintessential for the success of this model, as they assign both economic resources for salary support, as well as for the purchase of necessary equipment, and managing the resources of the trained personnel. Altogether, this cooperation across physicians, administration and government agencies has brought the management of acute care surgery patients in our region to the top tier.

Limitations

This was a retrospective, single-institution study. The experience with this model may be different in other parts of Latin America and the world. Unfortunately, more granular data regarding other clinical complications, readmissions and even some data regarding quality of care provided could not be gathered. Lack of robust electronic data bases makes it difficult to obtain such information. Data collection systems and trauma registries are the exception and not the norm throughout Latin America, including at the HVCM in Cuenca, Ecuador. Despite the initial economic support given to our initiative, there have not been sufficient resources to maintain a complete set of registrars to ensure the accurate capture of patient data. At the HVCM, patient information is scattered on paper and isolated independent digital servers that cannot interface with other electronic record systems. As such, data collection is not only labor intensive and time-consuming, but also difficult to impossible to obtain a large breadth of surgical outcomes. As such, our data did not allow us to examine outcomes such as surgical complications, incidence of conversion from laparoscopic to open procedures and exact cost to the system.

It is important to note that, coinciding with the development of our TACS model in Cuenca, a new prehospital care system in southern Ecuador, known as SIS ECU 9-1-1, was implemented. While this was enacted independently from the model that we are describing, this system improved patient care by standardizing prehospital transport. This represents a confounding factor within our study, as patient outcomes likely improved with more efficient transportation from the community to the hospital.

Conclusions

The TACS model implemented at our institution is the first to be described in an LMIC and in Latin America. It encompasses specialized surgical care directed at the management of trauma, surgical intensive care, emergency surgery and damage control surgery. This model has demonstrated a reduction in surgical wait times, decrease in length of stay and a decrease in mortality. It is fundamental to recognize the importance of administrative support for the assignment of resources as well as to understand the context and infrastructure in order to adjust this model to the local environment.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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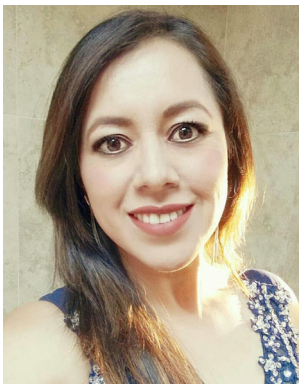

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