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Inhalation Injury: A Two-Year Pilot Assessment on the Adherence to the Clinical Pathway for Adult Burn Patients At High Risk for Inhalation Injury in the Philippine General Hospital

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Objective: This study determined the mean overall adherence to the clinical pathway formulated by the Section of Pulmonology together with the Division of Burns for adult burn patients at high risk for inhalation injury admitted at the UP-PGH ATR Burn Center in a two-year period.
Methodology: A retrospective cohort study regarding adherence to the clinical pathway of acutely burned adult patients at high risk for inhalation injury admitted at the UP-PGH ATR Burn Center between August 2016 to July 2018 was conducted. Medical records were reviewed and an adherence checklist was used to assess each item in the clinical pathway. For the adherence and patient profile, descriptive statistics were used.
Results: This pilot assessment study showed acceptable rates of adherence and implementation of the clinical pathway. Overall, 60% of the cases followed the clinical pathway completely. While 26.67% had acceptable rates of compliance (more than half of items adhered), while 13% of the cases scored adhered to less than half of the items.
Conclusion: The pathway has been shown to be a feasible clinical pathway that can be implemented in a tertiary hospital setting.

Keywords: Burns, inhalational injury, clinical pathway

Burn injuries remain a health care burden especially in developing countries. Inhalation injury continues to be a significant factor in morbidity and mortality for burn patients. Mortality rates have been shown to range from 30-41.5% if inhalation injury was present.[1] Among the most commonly used predictors for mortality in burns were age, burn size, and the presence of inhalation injury. Inhalation injury has been shown to increase the incidence of respiratory failure and acute respiratory distress syndrome, and is also the cause of early deaths for burn victims.

The Alfredo T. Ramirez Burn Center (PGH-ATR) is one of the largest burn units in the Philippines and admits more than 300 patients yearly. The Center is located at the Philippine General Hospital, a tertiary hospital which receives referrals from the whole country. A study done by Cruz, et al. in 2014 provided information on patient profile and prognostic indicators for inhalation injury patients treated at the Philippine General Hospital. The study looked into five years' worth of data and concluded that large burnt body surface area, delayed intubations, delayed resuscitations, and development of pneumonia were poor prognostic factors. The institution reported a mortality rate of 38.06%, which is still high compared to the global rates.[2]

Diagnosis and treatment of inhalation injury remains a challenge for burn specialists. Early recognition and prompt initiation of treatment, though mainly supportive,

are the cornerstones of management for inhalation injury. Awareness of the possible early and late complications of inhalation injury is equally important. Advancements in clinical practice and technology have greatly improved the survival rates of these patients. Previous data from the aforementioned institution showed mortality rates at 60% back in the early 2000s.

A multi-disciplinary approach is utilized in treating burns, especially inhalation injury. A dedicated team composed of the burn surgeon, pulmonologist, anesthesiologist, nursing staff and paramedical personnel are required in effective treatment of a burn patient. A joint study of the Division of Pulmonary Medicine and Division of Burns by Araneta-Cunada et al. developed a clinical pathway (Figure 1) in treating inhalation injury and has been implemented in the ATR Burn Center.[3] This pathway provides a guide for the burn specialist and highlights salient points in the history and physical examination when considering a diagnosis of inhalation injury. Guides on when to refer to a pulmonologist, what diagnostic procedures and laboratories to do, as well as which therapeutic intervention is necessary is highlighted in the clinical pathway. The pathway has been implemented in the Philippine General Hospital since August of 2016.

The aforementioned clinical pathway was formulated keeping in mind the limitations of the ATR Burn Center. The present study will assess the institution's adherence

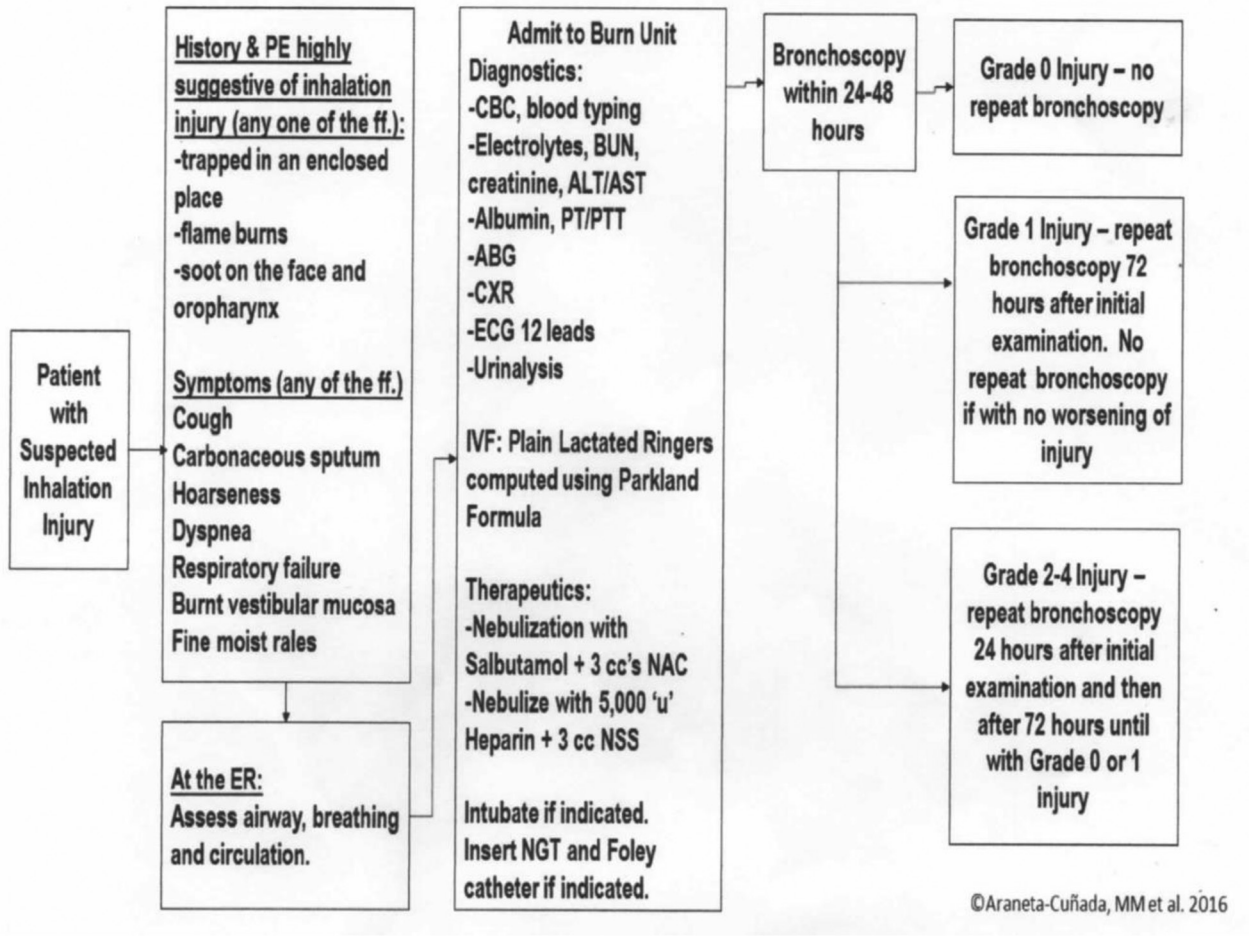

Figure 1.Clinical pathway for adult patients with inhalation injury.

and non-adherence to the clinical pathway and look into areas or factors for improvement. Presently, no study has been done to assess the pathway after its implementation.

The general objective of this study was to determine the mean over all adherence to the clinical pathway for adult burn patients high risk for inhalation injury admitted at the UP-PGH ATR Burn Center after its implementation from the period of August 2016 to July 2018. The specific objectives were: 1) to describe the demographic and clinical profile of patients coming in for inhalation injury who are targets of the clinical pathway; and 2) to determine the mean overall adherence rates to the clinical pathway for adult burn patients at high risk for inhalation injury.

Methods

The study is a retrospective cohort study of adult patients, 19 years old and over, admitted at the UP-PGH ATR Burn Center for burn inhalation injury during the two-year period of burn inhalation clinical pathway implementation (August 2016 to July 2018).

Inclusion criteria

All adult patients, 19 years and above, received at the ER within 48 hours of injury and suspected to have inhalation injury from the month of August 2016 to July 2018 were included in the study. Suspicion for having inhalation injury was based on risk factors taken from the history and physical examination of a patient. Information from the history that pointed to the diagnosis of inhalation injury included prolonged smoke or fire exposure, enclosed space, and loss of consciousness. Physical examination findings with a high index of suspicion included facial burns with singed nostril hairs, erythema/swelling of the oropharynx, presence of carbonaceous products, dyspnea, stridor, and hoarseness. Clinical judgment to diagnose the patient with inhalation injury based on the aforementioned information was done by a burn specialist. The presence of facial burns in the background of a flame injury, was considered high risk for inhalation injury. All information mentioned were collected from the department-wide database and patient medical records.

Exclusion Criteria

Adult patients who were received at the burn unit for more than 48 hours after injury and were low risk for having inhalational injury were excluded. Brief exposure to flame burns was classified as flash burns and was considered as low risk for the injury. The presence of facial burns in the background of a flash burn or brief exposure was considered low risk for inhalation injury. Pediatric patients, ages 18 and below, were excluded from the study.

The researchers analyzed data taken from the clinical profile of the patient and adherence to the clinical pathway. Variables under each category were obtained and are listed below. Information was obtained from patient chart records.

A. Patient profile
   1. Severity of burn in terms of % TBSA
   2. Inhalation injury grading: Grade 0, 1, 2, 3, 4
   3. Mechanism of burn: (i.e. flame, electrical)
   4. Presence of co-morbidities: (i.e. hypertension, diabetes)

B. Adherence to clinical pathway - Each patient record was reviewed and assessed on whether the following pathway parameters were done or not done at the time of referral or admission to the Burn Center:
   1. Assessed for presence of high risk features for inhalation injury upon admission
   2. Initiation of IVF resuscitation using Parkland formula upon admission
   3. Baseline diagnostics sent upon admission
   4. Use of prophylactic systemic antibiotic therapy
   5. Initiation of pharmacologic therapeutics (NAC, salbutamol and heparin nebulization) within 24 hours
   6. Referred to Pulmonary Medicine within 24 hours of admission
   7. Bronchoscopy and grading of injury within 48 hours of referral
   8. Repeat bronchoscopy done for qualified patients

The assessment of adherence to the pathway parameters was undertaken as listed in Table 2.

The researchers and a non-surgical research staff filled-up the adherence checklist (Table 3). The outcome measures were the following:

Table 2. Assessment of adherence to the pathway parameters.

Pathway Parameter	Measure of adherence
1. Assessed for presence of high risk features for inhalation injury upon admission	With notation of the absence/ presence of the following on the patient's chart: High risk features based on history: • Trapped in enclosed space • Flame burns High risk features based on physical examination and symptoms: • Presence of soot • Cough • Hoarseness • Dyspnea • Respiratory failure • Burnt vestibular mucosa • Fine moist rales
2. Initiation of intravenous resuscitation based on the Parkland Formula upon admission	Based on the patients weight and burned surface area, fluid hydration is initiated using Plain Lactated Ringers solution upon admission, with orders in the patient's chart and documentation of administration in the patient's therapeutic sheet or nurses' notes
3. Diagnostic laboratories	Baseline diagnostics sent upon admission With orders made on the patient's chart and presence of lab results on the chart or on review of the electronic laboratory portal (openMRS)
4. Use of prophylactic systemic antibiotic therapy	Initiation of prophylactic systemic antibiotics, with orders given in the patient's chart and documentation of antibiotic administration on the patient's therapeutic sheet
5. Initiation of pharmacologic therapeutics	Nebulization with: Salbutamol + 3cc NAC 5,000 'u' heparin + 3cc PNSS; with orders in the patient's chart and documentation of administration in the patient's therapeutic sheet or nurses' notes
6. Referral to pulmonology service	Referral to the pulmonology service within 24 hours of admission to the emergency room/ Burn Center, as documented on the patient's chart, with Pulmonary service notes
7. Bronchoscopy and grading of inhalation injury	Bronchoscopy done within 24-48 hours of admission, as documented by the bronchoscopy report on the patient's chart
8. Repeat bronchoscopy for qualified patients	Grade of 0-4 is given based on the Abbreviated Injury Score grading scale for inhalation injury on bronchoscopy, recorded in the patient's bronchoscopy report Grade 0 – no need for repeat bronchoscopy Grade 1 – repeat bronchoscopy after 72 hours of initial examination, no need for repeat bronchoscopy if with no worsening of injury Grade 2-4 – repeat bronchoscopy 24 hours after initial examination and then after 72 hours until with Grade 0 or 1 injury; as recorded on the patient's chart with the corresponding bronchoscopy reports

Table 3. Adherence checklist.

Patient No.	Age	Gender		
Mechanism of Burn	Percent Total Body Surface Area			
Co-morbidities				
Admission Date	Discharge Date			
Length of Hospital Stay: days				
Disposition: Discharged / Mortality	Reason for Mortality			
Item	**Yes**	**No**	**N/A**	**Comments**
Assessed for presence of inhalation injury				
Initiation of IVF resuscitation based on Parkland formula				
Diagnostics sent				
Use of prophylactic antibiotic therapy				
Initiation of pharmacologic therapeutics (NAC, salbutamol and heparin nebulization)				
Referred to Pulmonology service				
If yes, Number of hours from admission to referral time				
Bronchoscopy done within 48 hours				
Inhalation injury grading				
Repeat bronchoscopy done for qualified patients				
Number of items adhered to				

Individual Adherence – obtained by dividing the number of items adhered to by the total number of items expected for the patient.

Adherence rate per component – the number of patients who adhered to the particular item divided by the total number of patients in the study.

Overall Adherence – obtained by dividing the total number of items adhered to by the total number of items expected for all patients in the study.

The study protocol was submitted to the University of the Philippines Research Ethics Board (UPM-REB) for review and approval. The study commenced only upon receipt of a favorable decision from the UPM-REB. As the proposed study only involved a review of patient records and collected routinely documented data which were not considered sensitive data, an expedited review and a waiver of consent was requested from the UPM-REB. There was no direct participation from the patients.

The study requested for a waiver of informed consent since the study presented no more than minimal risk, the waiver or alteration would not adversely affect the rights and welfare of the participants, and the research cannot be practicably carried out without the waiver or alteration. The data obtained from the patient records were kept confidential, and the patients' identities were kept anonymous. These provisions were in accordance with the provisions stipulated in the 2017 National Ethical Guidelines for Health and Health-related Research.

While vulnerable patients were included in this study (i.e. elderly), the study only involved a review of their records for routinely collected, non-sensitive data and no additional intervention or burden was placed on them on the conduct of the study.

There were no patient identifiers included in the study data. Code numbers were assigned for each patient instead of their names and names were kept confidential.

There was no direct interaction with the patients. The inclusion in the study did not incur additional cost to the patients. All data sheets were secured and kept inside the hospital premises.

Data were entered into a password-protected Excel file in a password-protected laptop used specifically for this study. Only members of the study team had access to the Excel file. All study materials and documents were stored in a locked cabinet within the Department of Surgery offices.

Results

A description of the results is summarized in the tables below. The demographic and clinical profile of the patients included are summarized in Table 4. A review of the records from the 2-year period showed 38 patients that qualified for the study, among them only 30 medical records were available for review. The average ages were 38 years old, ranging from 20 to 69 years old. Majority of the patients were males (80%). Most of the mechanism of burns are flame injuries. Electrical injury patients had combined flame injuries from their burned clothing, while the lone scald injury had a history of steam exposure. Majority of the cases had total body surface area burns ranging from 21-60% burns.

Majority of the present cases had no established co-morbidities, since most patients are young or middle aged adults. Common co-morbidities observed were history of hypertension and methamphetamine use. Upon review, 33% of the patients expired and respiratory cause was usually attributed for the mortality.

For the assessment of clinical pathway adherence, a summary of the results and adherence rates is shown in table 5. There is a strict adherence (100% adherence rate) to the items pertaining to the initial assessment, resuscitation and diagnostic procedures (items 1-3). A gradual decrease in the compliance in the pathway is shown starting the 4th and 5th items pertaining to initiation of therapeutics and clinical diagnosis for inhalation injury. Upon review, cases wherein no treatment was started was for relatively stable patients with minimal to no facial burns and questionable history of prolonged flame or smoke exposure. For these aforementioned cases, no pulmonology referral was done.

For those referred to the pulmonology service, patients were seen at an average duration of 8 hours

Table 4. Demographic and clinical profile.

Variable	Frequency (%) n=30
Age (in years)	
Mean (±SD)	38.2 (±13.06)
Median (25th, 75th percentile)	37 (29, 47)
Gender	
Male	24 (80.00%)
Female	6 (20.00%)
Mechanism	
Flame	27 (90.00%)
Electrical	2 (6.67%)
Scald	1 (3.33%)
% Total Body Surface Area	
< 20%	6 (20.00%)
21-40%	8 (26.27%)
41-60%	10 (33.33%)
61-80%	3 (10.00%)
>80%	3 (10.00%)
Comorbidity	
With comorbidity	6 (20.00%)
No comorbidity	24 (80.00%)
Hospital length of stay (in days)	
Mean (±SD)	27.27 (±20.41)
Median (25th, 75th percentile)	27 (8, 40)
Disposition	
Discharged	20 (66.67%)
Mortality	10 (33.33%)
Cause of mortality	
Multi-organ failure	3 (10.00%)
ARDS	1 (3.33%)
ARDS on top of HAP	1 (3.33%)
ARF from HAP	1 (3.33%)
ARF from severe burns	1 (3.33%)
Sepsis from HAP	1 (3.33%)
Sepsis from ecthyma gangrenosum	1 (3.33%)
Fatal Arrhythmia	1 (3.33%)

Table 5. Summary of adherence to practices.

Item	Variable	Frequency (%) n=30	
		Yes	No
Q1	Assessed for presence of inhalation injury	30 (100%)	--
Q2	Initiation of IVF resuscitation based on Parkland formula	30 (100%)	--
Q3	Diagnostics sent	30 (100%)	--
Q4	Use of prophylactic antibiotic therapy	25 (88.33%)	5 (16.67%)
Q5	Initiation of pharmacologic therapeutics (NAC, salbutamol and heparin nebulization)	22 (73.33%)	8 (26.67%)
Q6	Referred to pulmonology service	25 (88.33%)	5 (16.67%)
Q6.1	Number of hours from admission to referral time, n=25		
	Mean (±SD)	7.8 (±4.0)	--
	Median (25^{th}, 75^{th} percentile)	8 (5, 10)	
Q7	Bronchoscopy done within 48 hours for qualified patients (n=25)	21 (84.00%)	4 (16.00%)
Q7.1	Inhalation Injury grading (n=22)		
	No injury	8 (36.36%)	
	Mild injury	9 (40.91%)	
	Moderate injury	3 (13.63%)	--
	Severe injury	2 (9.10%)	
	Massive injury	0	
Q8	Repeat bronchoscopy done for qualified patients (n=9)	8 (88.89%)	1 (11.11%)
Total	Total percentage of items adhered to		
	All (100%) items as applicable	18 (60.00%)	--
	Most (51%-99%) items as applicable	8 (26.67%)	
	Some (≤50%) items as applicable	4 (13.33%)	

after admission. Bronchoscopy was done within 48 hours of admission at 84% of the time. For the few cases that bronchoscopy was delayed, patients were either hemodynamically unstable or additional referrals to other co-managing services were needed to proceed with the procedure. Of these cases, coordination with the anesthesiology service was needed for assistance in sedation and mechanical ventilation during the procedure.

For the bronchoscopy results, approximately 22% belonged to AIS grade 2-4, while most of the results showed injury belonging to grade 0-1 (~78%). Important to note that the discrepancy in the number of inhalation grading and attempted bronchoscopy done was due to the fact that bronchoscopy was attempted in one of the cases however was deferred because a smaller sized scope was needed. For those requiring repeat bronchoscopy, almost all cases were done. Upon review, the sole case wherein repeat bronchoscopy was not done was because the patient was hemodynamically unstable for the repeat procedure.

Overall, 60% of the cases followed the clinical pathway completely. While 26.67% had acceptable rates of compliance (more than half of items adhered), while 13% of the cases scored adhered to less than half of the items.

Discussion

Despite advances in burn treatment, mortality rates remain high when inhalational injury occurs. Pathophysiologic changes occurring after inhalational injury can be summarized as injury to the upper and lower airways, pulmonary parenchyma and systemic toxicity.[4] Marked increase in survival from burn injury was explained by improvements in resuscitation, nutrition

therapy, wound management, and the introduction of early surgical excision. Despite these improvements, the cause of inhalation injury as an important cause for mortality is still to be explained. Numerous studies have provided data on mortality rates from burns ranging from 4% to as high as 15.8%, and citing inhalation injury as the most important predictor for mortality.[5]

The UP-PGH ATR Burn Center Clinical Pathway for Treatment of Inhalation Injury (Figure 1) was formulated to serve as a guide for management of inhalation injury since there were no published treatment protocols in the country at that time. The clinical pathway outlines the initial evaluation and upper airway management in patients suspected to have inhalation injury. It also stresses the importance of early bronchoscopy in diagnosis and management, as well as outlining other treatment modalities that are beneficial in inhalation injury. Burn victims presenting at the emergency room are deemed high risk for having inhalation injury based on history, physical examination and presenting symptoms. Assessment of the airway is prioritized and secured by early intubation if deemed necessary. Diagnostics such as blood work up (CBC, blood typing, electrolytes) arterial blood gas, chest radiographs, 12-lead electrocardiograph and urinalysis are obtained. Hydration based on the Parkland formula is initiated. Empiric antibiotics are started based on the specific burn unit's antibiogram, since resistance profiles for different hospitals may vary. It is the practice of the burn center to start broad-spectrum antibiotics to serve as pre procedure antibiotics (including bronchoscopy) and coverage for the bacterial profile of the center. Additional therapeutics in the form of nebulization with salbutamol, heparin and N-acetylcysteine is given. Bronchoscopy, both a diagnostic and therapeutic procedure, is done within 24-48 hours of admission, and is repeated based on the grading of injury. The scoring method being used by the institution is the abbreviated score grading Scale for inhalation injury (Table 1).[6] One of the recommendations of the study is evaluation of the clinical pathway once a significant number of patients have been studied. The clinical pathway had been implemented by the institution since August of 2016.

To date, the presented clinical pathway was the first algorithm in the Philippines formulated to treat patients high risk for inhalation injury. The pathway considered the unique needs of a tertiary hospital and formulated a treatment plan that can be implemented in its setting.

The clinical profile for patients coming in with inhalation burns, showed a male predisposition, who are relatively young, with no co-morbidities. Patients have a protracted length of hospital stay partly due to the associated severity of cutaneous burns. 33% of the acutely burned patient at high risk for inhalation injury expired, a finding that is consistent to the 38% mortality rate reported by the institution. If the clinical pathway had some effect on mortality rates, more data must be collected.

There is strict compliance for cases pertaining to assessment, resuscitation, and initial because this is standard practice for initial management for all burn patients, even those who are not high risk for inhalation injury. Management began as the patient was received at the ER even before the burn specialist was called. The burn specialist would then supervise, adjust or correct the initial treatment of the emergency room physician. A dip in adherence rates was seen during the initiation of therapeutics (antibiotics or adjunct treatments). The reason for non-compliance for initiation of treatment was that there may still have been a question in diagnosis of

Table 1. Abbreviated injury score grading scale for inhalational injury on bronchoscopy.

Grade	Class	Description
0	No injury	Absence of carbonaceous deposits, erythema, edema, bronchorrhea, or obstruction
1	Mild injury	Minor or patchy areas of erythema, carbonaceous deposits, bronchorrhea, or bronchial obstruction
2	Moderate injury	Moderate degree of erythema, carbonaceous deposits, bronchorrhea, or bronchial obstruction
3	Severe injury	Severe inflammation with friability, copious carbonaceous deposits, bronchorrhea, or obstruction
4	Massive injury	Evidence of mucosal sloughing, necrosis, endolumnial obstruction

inhalation injury. For clear-cut cases, the clinical pathway was strictly followed, however for cases wherein the diagnosis was unclear or questionable, there had been some deviation from the guideline. Patients may have some high risk features on history or physical examination but were clinically stable, thus in these cases, the burn specialist opted to observe for the progression of the condition and delayed treatment and consequent referral to the pulmonary medicine service. For the subset of cases where diagnosis was unclear, the pathway still suggested referral to the pulmonology service and initiateon of therapeutics. This usually resulted in the over-diagnosis of inhalation injuries as seen in the results of the study. In practice, the institution preferred to be over cautious rather than wait for potentially fatal complications to arise.

Initiation of prophylactic antibiotics is a unique practice in institutions burn center. Latest guidelines have stated that antibiotics are only started once the diagnosis of pneumonia has been made.[8] In comparison, it had been the standard of practice in the institution to start prophylactic antibiotics due to the high rates of hospital-acquired infections in the burn center. Broad-spectrum antibiotics were recommended as empiric treatment, and later shifted once culture results had been received.

The strict and judicious referrals to the pulmonology service show that intervention and treatment can be done in a timely manner. Causes for delay pertained to problems with logistics such as problems with coordination with co-managing services, availability of facilities and other hospital resources.

Burn injury remains a health care burden, due to a protracted length of hospital stay and further puts a strain on hospital resources. Due to the high cost of confirmatory examinations, diagnosis is mainly based on clinical evidence. Tertiary hospitals in other developing countries reported similar obstacles in the treatment of burn injuries. Patient focused issues such as financial and resource constraints, hospital system inadequacies such as lack of available man power, facilities and instruments, inadequate fire prevention protocols, all of which depict the universal challenges a burn specialist in a developing country must overcome to treat a burn patient.[9]

Conclusion

The cornerstone of treating inhalation injury is high risk of suspicion and low tolerance for intubation, which relies heavily on the experience and judgment of the burn specialist. With the clinical pathway in place, standardized and prompt treatment can be achieved. Adherence to the guideline reduces treatment variability and improves patient access to evidence-based care. This pilot assessment of the pathway provided information that proved that the clinical pathway can be implemented in a tertiary hospital setting.

The present study had insufficient number of patients to note improvement in clinical outcome for these burn patients. Future study designs may increase the duration of the study and look into the effect of the clinical pathway on inhalation injury mortality rates. Further revisions of the pathway may include inclusion of ancillary diagnostic tests and recommendations on antibiotic therapy.

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