Effect of Implementation of ADA/AACE Guidelines on the Management of Hospitalized Hyperglycemic Patients Through Training of Residents: A Tertiary Care Center Study

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Abstract

Background: Hyperglycemia is a common comorbidity in hospitalized patients and may add to adverse outcomes. Various associations have issued guidelines for optimal management of hyperglycemia in ill patients. This study aims to assess the adherence to current guidelines in inpatient setting and the impact of educational interventions on the improvement in adherence to guidelines as well as its effect on the level of blood sugar control and patient outcomes. **Materials and Methods:** It was a quasi-experimental pretest and posttest study and was done in three phases, viz., observation of current practices, intervention in the form of educational interventions, and its effect on change in practices and patient outcomes. **Results:** There was statistically significant 22% increase in the use of recommended insulin regimens ($P = 0.028$). The proportion of blood sugars within recommended range in the first 48 h, mean daily blood sugars, and the incidence of severe hyperglycemia improved in phase 3 vs phase 1 and was statistically significant. On comparing the subgroups, viz., those who followed and those who did not follow the guidelines, the results of the proportion of blood sugar in recommended range and proportions of blood sugar of more than 250 were found to be statistically significant. **Conclusion:** Dedicated educational interventions help in improving healthcare practices. According to current guidelines, rapid improvement in hyperglycemia and better glycemic control occur with adherence to protocol-based management of hyperglycemia.

Keywords: Education, Hyperglycemia, in patient

Introduction

Hyperglycemia is a common comorbidity in hospital admissions across all specialties. It can result either from underlying diabetes mellitus, ongoing medications, or stress-induced hyperglycemia secondary to increased release of cortisol.

Improved outcomes associated with intensive control of blood sugar have led American Diabetic Association (ADA) and American Association of Clinical Endocrinologists (AACE) to develop consensus recommendation for inpatient management of hyperglycemia.[1]

The main concerns in the management of hospitalized, critically ill, hyperglycemic patients include maintaining the blood sugars between 140 and 180 mg/dl, with insulin being the preferred agent for glycemic control, hourly monitoring of the blood sugars initially to prevent hypoglycemia in patients on insulin infusion, transition while they are shifted

to subcutaneous insulin regimen with a dose of 75–80% of the daily infusional requirement, and an overlap of 1–4 h with infusion before discontinuing it to prevent rebound hyperglycemia. In noncritically ill patients, it is recommended to use scheduled subcutaneous insulin therapy known as basal-bolus insulin therapy. Sliding scale insulin (SSI) should not be used as the standard of care in these patients. A number of studies in the past have concluded that SSI therapy is an ineffective mode of blood sugar control for hospitalized patients.[2] Use of oral hypoglycemic agents is not suitable,

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owing to the sickness of the admitted patients, organ injury present at the time of admission, need for faster correction of hyperglycemia, erratic food-eating patterns, drugs related to gastrointestinal effects, and the likelihood of hypoglycemic episodes.

In an Indian article by Gangopadhyay *et al*., consensus statement was issued, which suggested that intervention with scheduled subcutaneous insulin therapy using basal, bolus, and correctional insulin and avoiding SSI therapy are the key to effective management of inpatient hyperglycemia. A safe and effective transition of therapy between home and hospital setting based on hyperglycemic status is essential to avoid large variations in glycemic status.[3]

Despite the knowledge of the fact that good sugar control leads to better outcomes, the physicians often tend to take this issue as low priority.[4] Also, there is a lot of variability regarding the use of insulin[5] such as preferred use of SSI, inadequate use of insulin infusion, inadequate dosing of basal-bolus regimens, inadequate monitoring, and use of oral drugs for the management of hyperglycemia in inpatient intensive care unit (ICU) setting.

Moreover, the available literature on management of hyperglycemia in hospitalized patients is mainly from the Western part of the world. The body constitution, lifestyle, and dietary habits of Indians significantly differ from those of Western population.

Educating the healthcare providers regarding the practices of management and the need to improve these practices is a way to improve the healthcare at all levels. In a study conducted by Desimone *et al*.,[6] it was found that an educational Inpatient Diabetes Management Program for residents was effective at improving physician knowledge for managing hyperglycemia in hospitalized patients treated with corticosteroids or in preparation for surgical procedures. Educational programs directed at improving overall healthcare provider knowledge for inpatient glycemic management may be beneficial; however, improvements in knowledge do not necessarily result in improved glycemic outcomes. Moreover, simple teaching does not serve the purpose. We need to have a feedback regarding the improvement in an objective way, we need to understand the pitfalls in the applied methods based on nonadherence or partial adherence, further correct it, and observe the change till the desired results are not achieved. So, it is an ongoing process.

Equally important is the method used for educating. A single lecture or symposium may not be enough to convert the knowledge into practice.[7] Other methods may be needed, such as online learning,[8] computer-based interactive modules,[9] hands on workshops, use of posters and pamphlets highlighting the key issues.

So, our aim was to observe the difference in the practices of management of hospitalized hyperglycemic patients after educating the residents about the standard of care practices of management of such patients based on ADA/AACE guidelines.

MATERIALS AND METHODS

It was a quasi-experimental pre and posttest study done in three phases (6 months each), viz., observation of current practices of management of hyperglycemia, intervention to reinforce the ADA/AACE guidelines among the residents, nursing staff and assessment of compliance, and change in the outcomes observed.

The study was done in the Medicine ICU of a tertiary care hospital of North India over 2 years period, with 50 patients each in pre and postintervention group. The sample size was decided as a sample of convenience depending on the patient admission records of inpatient hyperglycemia in our hospital and the need to do the three phases of study in a short span of time to come to conclusions regarding the effect of educational interventions over a small group of residents.

Patients with persistent hyperglycemia, age >18 years, and hospital stay >48 hours in the Medicine ICU of our hospital were included in the study in a random fashion. The first phase involved a passive observation of the ongoing practices of management of hyperglycemia. Patients were assessed daily till hospital discharge or mortality. Patient's demographic variables, comorbidities, symptoms, clinical examination findings, disease severity scores at admission such as APACHE II (Acute Physiology and Chronic Health Evaluation) score and baseline investigations were documented.

Series of discussions and debates among the investigators led to the formulation of the plan of action for the intervention phase. The target group of interventional phase was identified to be the residents and the nursing staff of Medicine Ward and ICU. Content of the training material was developed after extensive review of literature and discussions by the investigators. Multiple methods were used to deliver the content using appropriate audio–visual aids. Interactive lectures were designed and delivered by the investigator after careful deliberation. Emphasis was laid on the accuracy, relevance, layout, and technique of presentation. A series of eight interactive lectures was organized. The groups consisted of 8–10 participants each. These lectures lasted for 25–30 min each. Audience involvement was encouraged and discussions were initiated in these sessions. A total of 70 residents were covered in the interactive sessions. One-to-one communication was followed up with the individual audience so as to remind them of the guidelines on management of hyperglycemia and for further clarifications.

The purpose of this intervention was to make the residents aware of the protocols regarding the inpatient hyperglycemia management in a practical and simplified manner. Overall, before the initiation of the third phase, it was ensured that all residents know the simple aspects of management of

inpatient hyperglycemia. This was done by one-to-one communication.

The adherence to the guidelines was assessed among the 50 patients. Data were collected by the investigator on a daily basis on all the recruited patients with the use of the proforma as used in the preintervention phase.

Quality indicators included proportion of patients in which recommended insulin regimen is used, proportion of blood glucose recordings within recommended range, mean daily blood sugar during hospital stay, number of episodes of severe hyperglycemia (>250 mg/dl), number of episodes of hypoglycemia (<70 mg/dl), and mortality.

Statistical analysis was done using STATA 11 software. For continuous variables, mean, standard deviation, and median were calculated. Continuous variables with parametric data were compared using *t*-test and nonparametric data were compared using Wilcoxon analysis. For categorical variables, frequency and percentage were calculated. Categorical variables were compared using Chi-square/Fisher's exact test. A *P* value of <0.05 was considered statistically significant in multivariable analysis.

RESULTS

The demographic distribution, clinical, and laboratory profile of the patients in both pre and postintervention groups were comparable, matched, and the difference was not statistically significant. This is shown in Tables 1 and 2.

Dyslipidemia, hypertension, coronary artery disease, and cerebrovascular accidents were the comorbidities in the decreasing order of prevalence in both the phases. Fourteen patients in phase 1 and 16 patients in phase 3 required mechanical ventilation. Patients requiring inotropic support were 8 and 12 in the two phases, pre and post, respectively.

In phase 1, the recommended insulin regimens were used in 18 (36%) of the patients, which increased to 29 (58%) in phase 3. This 22% increase was statistically significant (*P* = 0.028). Also, there was decrease in usage of sliding scale and premixed insulin in phase 3 when compared to phase 1, but the decrease was not statistically significant. This is summarized in Table 3.

The glycemic control was assessed in terms of proportion of the blood sugars within recommended range and mean daily blood sugar during the hospital stay. In phase 1, 54.7% ± 8.8 of the blood sugar recordings were within the recommended range, whereas it was 55.2% ± 5.8 in phase 3. There was no significant difference in glycemic control in terms of proportion of the blood sugars within the recommended range. However, mean daily blood sugar in phase 1 was 182 ± 26 mg/dl and in phase 3 was 164 ± 28 mg/dl and this difference was statistically significant (*P* = 0.001).

Also, the incidents of severe hyperglycemia (>250 mg/dl) were 19.95 ± 7.76% in phase 1 as compared to 13.94 ± 6.26% in phase 3. This decrease was found to be statistically significant.

The proportion of the blood sugars within the recommended range in the first 48 h was 46.7 ± 8.9 in phase 1 and 53.0 ± 8.8 in phase 3. This was statistically significant. In phase 1, six patients had at least one episode of hypoglycemia compared to eight in phase 3 and the difference was not statistically significant.

The findings comparing glycemic control in both groups are summarized in Table 4. There was no significant difference in the mortality between phase 1 and phase 3 (*P* = 0.76). The mortality and the survival groups were analyzed separately,

Table 1: Demographic and clinical profile of the patients

Variable	Phase 1 (Mean±SD)	Phase 3 (Mean±SD)	P
Age (years)	54.72±11.73	51.8±11.06	0.48
Gender: M:F	32:18	29:21	0.32
Heart rate (beats per minute)	99.12±11.92	101.2±16.1	0.21
Systolic blood pressure (mm Hg)	111.04±24.88	92.4±7.36	0.06
Risk ratio (breaths per minute)	17.64±11.92	16.14±8.4	0.73
Temperature (Fahrenheit)	99.04±0.94	98.1±1.1	0.65

Table 2: Laboratory parameters of the patients

Variable	Phase 1 (Mean±SD)	Phase 3 (Mean±SD)	P
Hb (g %)	10. 88±2.68	9.8±1.7	0.22
Total leukocyte count (per µl)	12648±6738	12744±6794	0.95
Platelets (per µl)	1.97±0.86	1.96±1.03	0.78
PT (sec)	14.43±2.17	14.5±2.1	0.08
Urea (mg %)	77.18±67.32	82.1±51.3	0.12
Creatinine (mg %)	1.64±1.9	1.31±1.07	0.33
Bilirubin (mg %)	1.47±1.27	1.68±0.68	0.994
Mean APACHE II score	25±5.27	27.9±4.2	0.12

Table 3: Insulin regimens used for glycemic control

Modes	Phase 1	Phase 3	P
Infusion+ or basal bolus	18 (36)	29 (58)	0.02
Sliding scale	18 (36)	12 (24)	0.19
Premixed	11 (22)	7 (14)	0.29

Table 4: Quality indicators comparison between phase 1 and phase 3

Variable	Phase 1	Phase 3
Mean of proportion of blood sugar within recommended range	54.7±8.8 (mean±SD)	55.2±5.8
Mean daily blood sugars	182±26 mg/dl	164±28 mg/dl
The proportion of the blood sugars within recommended range in the first 48 h	46.7±8.9 (mean±SD)	53.0±8.8
Severe hyperglycemia (>250 mg/dl) incidents	19.95±7.76%	13.94±6.26%
Patients with at least 1 episode of hypoglycemia	6	8

in an attempt to establish predictors of mortality, if any. Only APACHE II was found to be statistically different between the two groups. The *P* value for univariate analysis with regards to the APACHE II score was 0.01. The univariate analysis of the various mortality predictors is shown in Table 5.

A subgroup analysis between all the patients of phase 1 and phase 3 who followed the guidelines (*n* = 47) and who did not follow (*n* = 53) were done. The results are shown in Table 6. The results of the proportion of blood sugar in recommended range and proportions of blood sugar of >250 were found to be statistically significant.

DISCUSSION

Our study which is based on improving healthcare practice in ICU setting clearly demonstrated a positive impact of repeated educational meetings on adherence to protocols. This was depicted from statistically significant increased use of basal-bolus regimen and insulin infusions as the point of care in critically ill hyperglycemic patients. In the postintervention phase, the compliance to the overall use of guidelines increased by 22%. Even higher improvement could have been possible by ensuring that all the residents involved are actively participating in all the meetings and the education is converted into practice. A review was done by Forsetlund *et al.*[10] to assess the impact of educational meetings on professional practice by analyzing a total of 81 randomized controlled trials (RCTs) involving more than 11,000 healthcare

professionals. They concluded that educational meetings could improve healthcare practices and outcomes.

A review was done by Ivers *et al.*[11] to assess the impact of audit and feedback on the practice of healthcare workers by analyzing 140 RCTs. The analysis suggested that feedback may be more effective when baseline performance was low; the source is a supervisor or colleague, if provided more than once, if delivered in both verbal and written formats, and when it includes explicit targets and an action plan. In the present study, the investigators who were either seniors or colleagues of the audience provided feedback on the baseline performance. The feedback was provided on multiple occasions in multiple forums. The feedback did have an action plan aimed at the postintervention phase. So, educational meetings followed by effective feedback may help in increasing adherence to protocol-based guidelines.

Use of sliding scale is quite prevalent in the management of hospitalized hyperglycemic patients. This was also found in our study. In a study by Queale *et al.*,[2] sliding-scale insulin regimens when administered alone were associated with a three-fold higher risk of hyperglycemic episodes as compared with no therapies. So, current guidelines recommend against the use of sliding-scale regimens in hospitalized hyperglycemic patients.

A subgroup analysis was done in the present study, which compared the glycemic control between first 48 h and after 48 h. The glycemic control in the first 48 h was significantly better in phase 3 when compared to phase 1, indicating that the glycemic control can be achieved earlier if guideline-based insulin infusion and basal-bolus insulin protocols are followed for hyperglycemia management. Hermayer *et al.*[12] in a study concluded that with the institution of hospital-wide protocol of the use of insulin infusion and subcutaneous insulin in admitted patients, the percent time needed for blood sugar control decreased by 10% with no increase in the number or severity of hypoglycemic episodes.

There was significant decrease in episodes of severe hyperglycemia in phase 3. This also indicates that basal-bolus regimen helps in better glycemic control and incidence of severe hyperglycemia can be reduced. In a study by Umpierrez *et al.*,[13] it was concluded that a basal-bolus insulin regimen is preferred over SSI in the management of noncritically ill, hospitalized patients with type 2 diabetes.

Maynard *et al.*[14] in their study concluded that hypoglycemia and glycemic control can be improved simultaneously with structured insulin orders and management algorithms. Chen *et al.*[15] also demonstrated that following protocol implementation, hypoglycemic incidents significantly decreased, from 1.11 to 0.51 events per patient admission (*P* < 0.0025). In our study there was no statistical difference in the hypoglycemic events in both the groups. This may be due to the adequate blood sugar monitoring in the ICU setting and modifications in the insulin and use of prompt

Table 5: Predictors of mortality

Character		*P*
Systolic blood pressure	Mean±SD	0.47
Survivors	101.1±20.3	
Mortality	105.5±22.2	
Total leucocyte count	Mean±SD	0.19
Survivors	13039±6894	
Mortality	10400±5174	
Creatinine	Mean±SD	0.19
Survivors	2.0±1.6	
Mortality	1.6±1.0	
APACHE II	Mean±SD	0.01
Survivors	25.7±4.8	
Mortality	30.3±3.5	

Table 6: Subgroup analysis of adherent and nonadherent patients

Parameter	Adherent to regimen (*n*=47)	Nonadherent (*n*=53)	*P*
Proportion of BS in recommended range	58.2±7.1	52.2±6.5	<0.001
Proportion of BS >250 mg/dl	13.3±6.1	20.1±7.5	<0.001
No. of episodes of hypoglycemia	21	19	0.20
Mortality	06	07	0.63

treatment of hypoglycemia even before the setting of actual hypoglycemia.

There was no significant difference in mortality between the two groups in our study. But the study was not powered to calculate the effect of glycemic control on mortality. However, there is sufficient evidence in literature to support the worse outcomes and increased mortality in critically ill hyperglycemic patients. Mortality risk is greater in hyperglycemic patients without a history of diabetes.[16] Hyperglycemia induces vasoconstriction, inflammation, thrombosis, dehydration, fluid and electrolyte imbalances, and impaired gastric motility.[17]

Conclusion

Management of inpatient hyperglycemia according to the ADA/AACE guidelines improves the mean daily blood sugars, reduces the time in attaining the recommended blood sugar levels, and reduces the episodes of severe hyperglycemia during hospital stay.

Short-term comprehensive, educational activities directed at teaching the recommended practices improve the adherence to guidelines and may have long-term impact through continued appropriate practices and feedback.

Limitations of the study

The duration of the study was short, with a small sample size to look for the effect of protocolization of the hyperglycemia management. This study had a quasi-experimental design and was a nonrandomized study. The adherence to guidelines was entirely voluntary and was not audited. In this study, barriers to compliance improvement were not measured.

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Conflicts of interest

There are no conflicts of interest.

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