Traumatic injuries in patients with diabetes mellitus

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ABSTRACT

Diabetes mellitus (DM) is associated with increased in-hospital morbidity and mortality in patients sustained traumatic injuries. Identification of risk factors of traumatic injuries that lead to hospital admissions and death in DM patients is crucial to set effective preventive strategies. We aimed to conduct a traditional narrative literature review to describe the role of hypoglycemia as a risk factor of driving and fall-related traumatic injuries. DM poses significant burden as a risk factor and predictor of worse outcomes in traumatic injuries. Although there is no consensus on the impact and clear hazards of hyperglycemia in comparison to the hypoglycemia, both extremes of DM need to be carefully addressed and taken into consideration for proper management. Moreover, physicians, patients, and concerned authorities should be aware of all these potential hazards to share and establish the right management plans.

Key Words: Diabetes, fall, hyperglycemia, hypoglycemia, traffic injury, trauma

INTRODUCTION

Diabetes is a major public health problem worldwide.1-3 A systematic analysis of health examination surveys and epidemiological studies had estimated the global prevalence of diabetes mellitus (DM) to be 347 million in the year 2008.4 Higher prevalence was reported from South Asia, Latin America, Caribbean, Central Asia, North Africa, and Middle-eastern region. Age-standardized prevalence of DM was 9.8% in adult men and 9.2% in women.5 The World Health Organization estimated that 3.4 million people died annually from the consequences of DM and 80% of these deaths occur in low- and middle-income countries.6 Type-2 DM accounted for more than 90–95% of these cases which are usually associated with old age, obesity, physical inactivity, and family history of Type-2 DM or a personal history of gestational diabetes.7

Traumatic injuries in DM patients are often associated with increased hospital length of stay and mortality.4-7 Motor vehicle crashes (MVCs) and falls are common causes of traumatic injuries and deaths,6 and hence these two injury mechanisms are of major concern among diabetics. Evidence suggests that poor mobility and cognitive and visual impairment are major risk factors for MVCs in DM patients.9 Similarly, decreased peripheral nerve function, impaired vision, and renal dysfunction are the main,10 risk factors attributed to falls.10 These risk factors are primarily related to hypoglycemic conditions associated with antidiabetic therapy.11-14 Herein, we reviewed the current published literature to describe the role of hypoglycemia as a risk factor for driving and fall-related traumatic injuries.

METHODS

A traditional narrative literature review was conducted for peer-reviewed articles published between January 2000 and December 2015. Electronic databases such as PubMed, MEDLINE, and Google Scholar were used for the literature search. This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

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search using keywords such as “Diabetes,” “Hypoglycemia,” “Driving,” “Motor vehicle crash,” “Road traffic injury,” “Falls,” and “Trauma.” Additional manual bibliographic search of identified relevant articles and web searches were also performed. The literature search yielded 131 potential articles; 68 were MVC-related and 63 were fall-related injuries which were reviewed for inclusion. The study included original articles based on hospital data; ten MVC-related and nine falls-related articles were considered for analysis. The study population in MVC-related studies was mainly drivers in which the driving impairment caused by diabetic complications was addressed. Studies based on self-reported driving impairment, self-reported falls, community-based surveys, and qualitative studies were excluded from the study. All the MVC-related studies were based on case–control analysis, whereas 5 out of 9 fall-related studies had controlled study design. Interestingly, around half of the articles included were originated from the United States [Table I].

**DISCUSSION**

**Prevalence and outcomes of hypoglycemia**

Hypoglycemia refers to the low blood glucose level which is the most significant complication of DM. Severe hypoglycemia while driving may result in neuroglycopenia that disrupts cognitive motor function which increases the risk of injury and mortality. It may also induce adrenergic symptoms such as nervousness, tremor, tiredness, confusion, and retarded mental function.

Hypoglycemia is often associated with intensive insulin treatment in DM patients. A three-fold increase in severe hypoglycemia was reported in intensively treated patients when compared with conventionally treated patients. Approximately 90% of the patients receiving insulin therapy are likely to be experienced hypoglycemic episodes. Insulin therapy in Type-1 DM may cause 10 episodes of symptomatic hypoglycemia per week whereas severe hypoglycemia causing temporary disability occurs at least once a year. Hypoglycemia is responsible for 2–4% of deaths in DM patients and 6–10% in Type-1 DM. The risk of death is not only limited to the Type-1 DM patients undergoing intensive therapy but also occurs in Type-2 DM. In clinical trials, the prevalence of hypoglycemia in insulin-treated Type-2 DM is estimated to be 70–80%.

**Pathophysiology of hypoglycemia**

Variations of blood glucose level may influence the cognitive brain function. Brain is the first organ to be affected with deprivation of energy due to hypoglycemia. Under such conditions, a sequence of responses will be initiated to protect the brain. The normal physiologic range of plasma glucose is 4.4–4.7 mmol/L. When it falls below this range, insulin secretion by the pancreatic β-cells will decrease. This favors increased production and decreased utilization of glucose by tissues other than the brain. Lowering of blood glucose level below the physiologic range (3.6–3.9 mmol/L) results in a release of hepatic and epinephrine glucagon which favors glycogenolysis and gluconeogenesis. Consequently, glucose utilization by insulin-sensitive tissues will be limited. Further lowering of glucose concentrations below 2.8–3.0 mmol/L cause neurogenic (sweating, shakiness, tachycardia, anxiety; and sensation of hunger) and neuroglycopenic (weakness, tiredness, or dizziness; inappropriate behavior; confusion; and impaired vision and concentration) symptoms of hypoglycemia. Brain dysfunction (coma and death in extreme cases) will occur at levels <2.8 mmol/L. However, these thresholds shift to higher blood glucose levels in individuals with poorly controlled diabetes and lower concentrations in patients who experience recurrent hypoglycemia. Notably, recurrent hypoglycemia is more likely to occur in patients with well-controlled diabetes or with endogenous hyperinsulinism.

**Motor vehicle crash-related injuries in diabetic patients**

Several investigators have recognized the association between MVCs and DM. A recent meta-analysis demonstrated that diabetic patients were at 12–19% higher risk of MVCs. Impaired vision caused by retinopathy or cataract formation as well as neuropathy that affects the ability to feel foot pedals contribute to this increased risk of MVCs in DM patients. The risk in Type-1 DM patients is almost twice that of nondiabetic drivers. However, some studies revealed that patients with other medical conditions such as attention deficit/hyperactivity disorder and obstructive sleep apnea are at increased risk of MVCs than DM patients.

Early reports by Crancer and McMurray and de Klerk and Armstrong revealed increased risk of MVCs in young diabetic patients. A high-risk ratio of hospital admission was reported in DM drivers as well as pedestrians under the age of 55 years. Head injury was often reported among DM patients of this age group. Mortality was slightly higher than expected for men; however, no evidence for increased risk of trauma was reported in women and older men with DM.

A Norwegian prospective follow-up study reported that 24 out of 1000 MVCs occurred in DM patients. This study included all Norwegians aged 18–69 years (3.1 million) and followed for more than 2 years. Young DM patients (18–34 years) were more likely to be involved in MVC. The authors concluded that there is no evidence for increased risk of MVCs in elderly DM patients.

Case–control studies published in the last 15 years also demonstrated that DM patients are at increased risk for MVCs than non-DM controls. [Table I]. Laberge-Nadeau et al. demonstrated that diabetic patients controlled for risk exposure have an increased crash risk of 1.76 when compared to nondiabetics. Songer and Dorsey also demonstrated that crash frequency in DM was significantly higher than controls. The study by Laberge-Nadeau et al. included a large sample size of diabetic truck-permit holders whereas Songer and Dorsey study
Table 1: Studies related to traumatic injuries from motor vehicle crashes and falls in diabetic patients

| Reference (year)        | Origin      | Study design | Study population | Outcomes                                                                 | Concluding remarks                                                                 |
|-------------------------|-------------|--------------|------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| Laberge-Nadeau et al.156(2000) | Canada      | Case–control | 4495 with DM versus 8938 non-DM | DM controlled for risk exposure; have an increased crash risk of 1.76 when compared with nondiabetics | Insulin use is not associated with higher crash risk. |
| Kennedy et al.106(2002)  | UK          | Case–control | 152 insulin-treated DM versus 25,093 Non-DM+DM controlled with diet and/or oral hypoglycemic | MVC rate nonsignificantly higher in cases than controls | Insulin-treated DMs are at increased risk of accidents, mainly due to low-impact falls. |
| Cox et al.107(2003)     | The United States, Switzerland, Germany | Case–control | 341 Type-1DM, 332 Type-2 DM, and 363 non-DM | Type-1 DM drivers had more episodes of hypoglycemic stupor and crashes compared to Type-2 DM drivers | Type-2 DM on insulin is not at increased risk for crashes than non-DM individuals. |
| Songer and Dorsey48(2006) | United States | Case–control | 67 Type-1 DM versus 336 non-DM | Crash frequency in DM was significantly higher than controls | Factors influencing crashes in persons with diabetes may change over time. |
| Lommen et al.166(2008)  | UK          | Case–control | 521 DM versus 28956 non-DM | The relative risk of car accidents for DM was 0.58 (CI 0.54–0.63). Within the insulin-treated DM group (n=121), no significant difference in the accident rate compared to the non-DM | Insulin-treated patients as a group do not pose an increased risk to road safety. |
| Skurtveit et al.164(2009) | Norway      | Case–control | 183 insulin only-treated DM; 219 oral antidiabetic drugs-treated DM; 643 non-DM treated for GERD | Standardized incidence ratio; insulin 1.4 (1.2–1.6), oral glucose-lowering agents 1.2 (1.0–1.3), and non-DM GERD 1.3 (1.2–1.4) | Increased risk observed for insulin users was similar to that observed for users of drugs for peptic ulcer and GERD. |
| Redelmeier et al.164(2009) | Canada      | Case–control | 57 DM cases involved in a crash versus 738 DM controls not involved in a crash | The mean HbA1c was lower for cases than controls, equal to a 26% increase in the relative risk of a crash for each 1% reduction in HbA1c | Tighter glycemic control is associated with an increased risk of MVC. |
| Cox et al.16(2010)      | United States | Case–control | 16 Type-1 DM with history versus 22 Type-1 DM without history of recurrent hypoglycemia-related driving mishaps | Participants with history had more autonomic and neuroglycopenic symptoms | Type-1 DM drivers more vulnerable to experiencing hypoglycemia-related driving mishaps. |
| Campbell et al.16(2010) | United States | Case–control | 16 Type-1 DM with history versus 22 Type-1 DM without history of driving mishaps | Poor neurocognitive function in patients with history of driving mishaps | Working memory is a potential neurocognitive indicator that predicts future risk for driving mishaps. |
| Signorovitch et al.16(2013) | United States | Case–control | DM patients who had accident; 5582 versus 27,930 without hypoglycemia | Hypoglycemia was associated with increased hazards for any accident (falls: HR 1.36, 95% CI 1.13–1.65, P<0.001, and MVCs: HR 1.82, 95% CI 1.18–2.80, P=0.007) | In Type-2 DM patients receiving drugs without insulin, hypoglycemia was associated with a significantly higher risk of accidents resulting in hospital visits, including MVCs and falls. |
| Schwartz et al.164(2008) | United States | Prospective | 446 DM (older) | Low AsC in insulin users (4.36 [3.32–4.46], AsC56 vs. >8%) were associated with risk of falls | Oral hypoglycemic medications were not associated with more frequent falls, but AsC56% increases the risk of falls in insulin users. |
| Johnston et al.166(2010) | United States | Case–control | 344,274 DM with and 16,936 DM without hypoglycemia | Hypoglycemic DM had higher regression-adjusted odds for fractures than nonhypoglycemic DM (OR=1.70, 95% CI=1.58–1.83) | Hypoglycemic events were independently associated with an increased risk of fall-related fractures. |
| Oliveira et al.166(2012) | Brazil      | Case–control | 30 Type-2 DM and 68 non-DM | DM was associated with reduced mobility and reduced visual acuity other than non-DM (P<0.05) | Increased fall risk even in younger patients and in those with shorter disease duration. |
| Vaz et al.166(2013)     | Brazil      | Case–control | 32 DM versus 32 non-DM | Postural control and functional strength deficits in DM group vs. non-DM | Subjects with DM, with or without diabetic neuropathy, showed deficits in postural control and functional strength. |
| Yau et al.166(2013)     | United States | Prospective | 602 insulin using DM patients; 127 noninsulin DM; 2356 non-DM | Fall injury rate in was higher in DM versus non-DM (HR 1.48 [95% CI 1.12–1.95] in insulin user DM versus non-DM (HR 3.00 [2.78–5.27]) | Older DM insulin users are at greater risk of fall injury than non-DM. Poor glycemic control in DM may increase the risk of traumatic fall injury. |
surveyed a smaller group of Type-1 DM patients. In contrast, Joseph et al. demonstrated that MVC involvement within the prior 2 years of the study was the strongest predictor of future MVCs. In this study, DM was not listed as a risk factor, but depression, falls within the previous year, sleep apnea, and lower baseline systolic blood pressure were observed as associated risk factors for MVCs.

**Hypoglycemia as a major risk factor for motor vehicle crashes**

Hypoglycemia is one of the major risk factors for traumatic injuries in DM patients. It is associated with inefficient driving performance due to compromised psychomotor skills, visuospatial functions, rapid information processing, vigilance, and satisfactory judgment. Therefore, hypoglycemic attacks with giddiness or fainting may lead to attention dysfunction resulted in fatal MVCs. This issue becomes further complicated when some individuals with DM decide to drive when they are aware of their hypoglycemic state.

Insulin-induced hypoglycemia in Type-1 DM during intensive insulin therapy is a common clinical finding. A multinational survey conducted by Cox et al. demonstrated that drivers with Type-1 DM experienced frequent hypoglycemic episodes during MVCs when compared with Type-2 DM drivers. This study added that Type-2 DM patients on insulin treatment had similar risk of MVCs than non-DM individuals. A prospective study by these researchers found 52% of the Type-1 DM drivers had at least one hypoglycemia-related MVCs and 5% reported six or more incidents. These accidents were related to driving duration, history of severe hypoglycemia, and use of insulin pump therapy. A multinational survey by the same group revealed that MVCs among Type-1 DM drivers were associated with frequent hypoglycemic attacks while driving, infrequent blood glucose monitoring before driving, and use of insulin injection therapy instead of pump therapy.

Cox et al. also investigated the relationship between blood glucose level and driving performance in 25 drivers with Type-1 DM. Blood glucose levels were manipulated using intravenous insulin administration. Participants were blind to their actual blood glucose levels. Impaired driving performance was not observed with mild hypoglycemia (mean blood glucose, 3.6 ± 0.33 mmol/l) but was evident for moderate hypoglycemic state (mean level of 2.6 ± 0.28 mmol/l). Global driving performance impairment was observed in 35% of the study participants. Weinger et al. demonstrated that the proportion of patients to judge their safe driving ability decreased with reducing serum glucose levels (70% at 6.7 mmol/l to 22% at 2.2 mmol/l) in patients underwent insulin therapy. The study showed that males and middle-aged subjects considered driving to be safe with hypoglycemia as compared to females and subjects under the age of 25 years.

A simulation study revealed that Type-1 DM drivers adopted corrective measures with self-treatment only when blood glucose reduces below 2.8 mmol/l. Self-treated drivers experienced less neuroglycopenia during driving when compared to untreated drivers. Driving impairment was not associated with age, sex, duration of diabetes, average miles driven in the past years, driving experience, and self-reported crashes.

Redelmeier et al. study adjusted the potential confounders such as blood glucose monitoring, complications, and treatments and then found that the glycosylated hemoglobin (HbA1c) level was lower for DM patients involved in MVCs. They reported 26% increase in the relative risk for MVC for each 1% reduction in HbA1c. History of severe hypoglycemia requiring outside assistance and delayed diagnosis of diabetes were the two other significant risk factors for MVCs. The investigators pointed out that hypoglycemia-related neuroglycopenia disrupts cognitive-motor functioning that impairs driving performance. Cox et al. found that Type-1 DM drivers with a history of recurrent hypoglycemia had more autonomic and cognitive impairment compared to Type-2 DM drivers.
neuroglycopenic symptoms than those without any history of recurrent hypoglycemia.\[23\]

An earlier study identified that previous episode of severe hypoglycemia, history of hypoglycemia while driving, low HbA1c, and absence of blood glucose monitoring prior driving are some of the factors that could increase the risk of MVC in diabetics.\[55\] Campbell et al. revealed that poor neurocognitive function was associated with multiple recent hypoglycemia-related driving mishaps in Type-1 DM patients.\[23\]

Oral antidiabetic drugs associated hypoglycemia
Metformin is the first-line drug of choice for the treatment of Type-2 DM. This is often prescribed in overweight and obese patients with normal kidney function.\[34\] Sulfonylurea is another oral antihyperglycemic drug prescribed for patients who cannot take metformin or if the patient is not overweight.\[35\] Hypoglycemia was reported nearly 3 times more with sulfonylurea when compared to metformin.\[37\] Zammitt and Frier demonstrated that hypoglycemia in Type-2 DM is a significant problem associated with insulin or sulfonylurea therapy. Signorovitch et al. observed a significantly higher risk for MVCs in Type-2 DM patients with hypoglycemia receiving antidiabetic drugs other than insulin.\[34\] Increased hazards for accidents were seen in DM patients younger than 65 years and greater risk of fall in elderly (>65 years). In contrast, Skurtveit et al. showed no difference in MVC incidence between sulfonylurea or metformin users within the general population.\[24\] They showed that the increased risk for MVCs associated with insulin use was similar to that of drugs used for peptic ulcer and gastroesophageal reflux disease.

Hypoglycemia unawareness as a risk factor for trauma
Awareness of an early hypoglycemic state in drivers with Type-1 DM is crucial to sustain driving performance. The time span between the detection of hypoglycemic symptoms requiring self-treatment and the onset of neuroglycopenia is too short while driving. Neuroglycopenia affects negatively on the ability to make judgments and causes decrements in mean reaction time. Cox et al. showed that less than half (44%) of Type-1 DM drivers were aware of their hypoglycemia, and only one-third of them were involved in self-treatment to avoid poor driving performance.\[44\]

The physician advice patients who are unaware of hypoglycemia to stop driving until the condition is reversed. If the risk is confirmed, the physician should also consider informing about this condition to the concerned authorities. Therefore, knowledge about hypoglycemia awareness among the healthcare professionals is crucial and requires regular educational newsletters. A Scottish study revealed that 62% of the healthcare professionals believe that insulin-treated drivers should check their blood sugar levels before driving; whereas 13% consider safe to drive with blood glucose <72 mg/dl and 8% did not know that hypoglycemia might affect safe driving.\[39\] Therefore, facilitating awareness of healthcare professional about the contraindication of driving during hypoglycemic state may improve the hypoglycemia awareness in patients. Harsch et al. reported that nearly half of drivers with Type-1 DM never discussed driving issues with their physicians.\[57\] However, this issue was more prominent in Type-2 DM as 75% patients have not discussed their conditions with the physician. It has been reported that unawareness of hypoglycemia in Type-1 DM patients was related to increased incidence of MVCs. On the other hand, some investigators considered unawareness of hypoglycemia to be a relevant issue.\[49\]

Evidence-based driving restrictions in diabetic patients
Considering the risks for MVCs associated with DM, some authorities reviewed their guidelines for driving fitness assessment and implemented some licensing restrictions on drivers known for DM. Some studies have suggested no incremental risk for road safety by insulin-treated DM patients.\[81,82\] Similarly, a retrospective study showed that diabetic drivers treated with insulin and attending clinics had no greater risks for MVCs than nondiabetic subjects.\[10\] Nearly 31% of insulin-treated DM patients had recognized hypoglycemic symptoms while driving, and only 11.7% reported hypoglycemia as a cause of accident. The register-based prospective study reported a major excess of injuries in insulin-treated patients mainly related to low falls (62.3%).\[10\] However, this excess was not significant for MVCs as only 15.2% of insulin-treated were involved in MVCs.

Lonnen et al. estimated the annual incidence rate of MVCs for non-DM and DM populations as 1469 and 856 per 100,000 DM patients, respectively.\[19\] The authors observed nonsignificantly statistical difference in the accident rate between the insulin-treated DM and non-DM subjects. The recent history of severe hypoglycemia irrespective of the type of diabetes or treatment is the most significant factor associated with MVCs.\[8,83\]

Therefore, National Highway Traffic Safety Administration (NHTSA) recommended glycemic evaluation of all DM patients who seeks for a license. Contrarily, the American Diabetes Association (ADA) being a patient advocacy group in the United States opposed the notion of screening of all diabetic patients.\[84\] They advocated that many people with DM do not experience hypoglycemia because of their treatment regimen. Hypoglycemia is mainly observed in individuals taking insulin or certain classes of oral medications. In addition, NHTSA identified hypoglycemic unawareness to be related with driving incompatibility. This was opposed by ADA, arguing that a 2–3-week period of careful
avoidance of hypoglycemia is enough to regain hypoglycemic awareness.\textsuperscript{[13,64]}

Moreover, a person with hypoglycemic unawareness can drive safely with precautions, such as blood glucose monitoring before driving and continue to test on hourly basis during longer drives. It has been recommended that drivers should interrupt their trip if they feel symptoms nearing hypoglycemia or the blood sugar reduces below 4 mmol/dl.\textsuperscript{[65-69]} In general, it is agreed that DM patients are at increased risk for MVCs as hypoglycemia causes driving impairment, retinopathy, or cataract (impaired vision) and diabetic neuropathy affecting the ability to feel foot pedals. Therefore, it is important to minimize MVCs in DM patients through education, public awareness, law enforcement, and adopting new technology. For instance, Kerr and Olateju proposed the development of in-vehicle medical monitoring which will have potential impact on safe driving.\textsuperscript{[90]}

**Diabetes and risk of fall-related injuries**

Falls remain a major public health problem with significant morbidity and mortality, especially in the elderly population. According to WHO (2007), fall can be defined as “inadvertently coming to rest on the ground, floor, or other lower level, excluding intentional change in position to rest in furniture, wall, or other objects.”\textsuperscript{[66-69]}

The probability of traumatic injury in a fall is determined by the distance of the fall, orientation on falling, landing surface, and whether the fall was broken. Falls from heights are common in the occupational settings which depend on faulty equipment (ladders) and human factors (inattention and intoxication). Fall-related head, spine, and extremities injuries are more frequent and even low-level falls may result in serious head injuries.\textsuperscript{[66-69]} Falls from a height of more than 20 feet usually triaged in trauma centers, and approximately 10% of all falls resulted in fractures, lacerations, head injuries, and even death.

Inadequate glycemic control as well as insulin use in diabetics increases the risk of fall-related fractures.\textsuperscript{[70]} Duration of DM and presence of complications are also important factors for additional risk of injuries. Microvascular complications associated with DM also increases the risk of falls in elder population. Notably, peripheral neuropathy that leads to postural instability is an independent risk factor for falls.\textsuperscript{[71]} Further, diabetic retinopathy is the leading cause of impaired vision which increases the risk of falls. In addition, renal dysfunction was also identified as a risk factor of falls.\textsuperscript{[72]}

Elderly individuals are more likely to have DM which increases the risk of falls.\textsuperscript{[72-74]} Together with poor bone health, microvascular complications of DM may result in devastating consequences such as bone fracture, deteriorating quality of life, and among elderly population. An earlier study showed that females above 60 years of age with diabetes are more likely to fall (1.6 times) as compared to nondiabetic females.\textsuperscript{[74]} Another prospective cohort study showed an increased risk of falls in elderly diabetic patients over 60 years of age.\textsuperscript{[75]} The incidence rate of falls during the mean follow-up period (299 days) was significantly higher in patients with DM as compared to non-DM patients (78% vs. 30%, \( P < 0.001 \)).

**Hypoglycemia and risk of falls**

Insulin therapy has been identified as a risk factor for falls in the elderly population along with other risk factors such as age, imbalance, prior history of cardiovascular disease, osteoarthritis, peripheral neuropathy, higher body mass index, and poor performance of lower extremities.\textsuperscript{[11,64]}

Johnston et al. conducted a case–control study which compared of 344,274 DM patients with hypoglycemia and 16,936 DM patients without hypoglycemia.\textsuperscript{[76]} The authors found that hypoglycemic events were independently associated with an increased risk of fall-related fractures in DM patients. Similarly, Yau et al. reported that DM patients underwent insulin therapy were at increased risk of fall-related traumatic injuries than those without diabetes.\textsuperscript{[79]} Kennedy et al. attributed the increased risk of accidents in DM patients to falls from a short distance (<2 m).\textsuperscript{[80]} Insulin-treated DM patients had 62.3% excess of risk for accidents in comparison to 47.1% in control population (\( P < 0.01 \)).

Signorovitch et al. also showed increased hazards for accidental falls among Type-2 DM population.\textsuperscript{[81]} The study revealed that in Type-2 DM patients receiving noninsulin drugs, hypoglycemia was associated with a significantly higher risk of falls leading to hospital visits. However, Schwartz et al. demonstrated that oral hypoglycemic medications were not associated with frequent falls in elderly population.\textsuperscript{[82]} Rather, it was HbA1C level (\( \leq 6\% \)) that increases the risk of falls in these patients. The increased risk of fall-related injuries in older DM patients was also evident in another study suggesting that the risk was mainly associated with poor glycemic control.\textsuperscript{[83]} A recent, retrospective, cohort study also demonstrated worst fall-related outcomes in elderly patients with Type-2 DM.\textsuperscript{[84]} Kachroo et al. reported that hypoglycemic patients had elevated risk for head injuries, fall-related outcomes of fractures, hospital admissions, and longer duration of care.\textsuperscript{[85]}

Fu et al. recently showed an increased risk for hypoglycemia-related hospitalizations in older patients using both insulin and sulfonylurea drugs.\textsuperscript{[86]} It has been demonstrated that Type-2 DM was associated with reduced mobility and visual acuity and these patients are at increased risk for falls even at young age with shorter duration of DM.\textsuperscript{[87]} In line with this study, Lu et al. reported an increased risk of falls in patients with DM.\textsuperscript{[81]} In addition, the excessive risk for traumatic injuries was more evident in individuals younger than 65 years of age. This comparative study included 31,049 DM patients in each group such as DM without severe hypoglycemia, DM with severe hypoglycemia, and non-DM patients. The study demonstrated that age, sulfonylurea use, insulin use, and renal disease predict hospitalizations associated with hypoglycemia. Vaz et al. found postural control and functional strength deficits in DM patients when compared with non-DM subjects.\textsuperscript{[88]} These deficits were evident in DM patients regardless of the presence of diabetic neuropathy.
Although hyperglycemia is related to cognitive, visual, balance, and mobility impairments, the evidence for linking hyperglycemia to fall-related injuries is limited due to lack of controlled clinical trials.

Limitations
Several study designs adopted to establish the relationship between DM and MVCs or fall-related injuries have potential strengths and biases. The advantage of retrospective cohort studies is that the exposure to risk factors is documented prior the occurrence of the outcome. However, these observational studies often depend on self-reporting and therefore fail to distinguish between types of diabetes. Further, in observational studies, only association could be inferred from the results but not the causality. Therefore, the observed association between DM and MVCs or fall-related injuries may have been biased by unknown confounding factors. On the other hand, experimental studies such as controlled clinical trials subjects are randomly enrolled either to the study or control group which minimize selection bias and also control for other confounding factors right from the beginning. Hence, lack of randomized controlled clinical trials is an important barrier to establish these associations. Hence, the risks for MVCs or fall-related injuries in hyperglycemia were inadequately addressed due to lack of comparative data.

The incidence of MVCs increases with increasing number of road users over time and even a decade old study may reflect findings that are very much different from today. In addition, 20–30 years old studies may not represent current practices on diabetes management. Therefore, we assume even a decade old study may not capture the rapidly increasing number of road users and fast advancements in diabetic management. Therefore, it is clearly seen that in many countries, the incidence of both DM and MVC is increasing exponentially which poses a great challenge for healthcare authorities and resources.

Another limitation is the lack of consensus on the definition of falls in earlier studies. Most investigators fail to specify the operational definition of falls. In addition, interpretation of falls was left to study subjects and consequently the validity of studies is often challenging. The most vulnerable group for the occurrence of falls is elderly population which describes its occurrence due to loss of balance. Meanwhile, healthcare professionals refer to the consequence of falling such as injury and reduced quality of life. It is clear that even a small change in definition may have high impact on the findings of a study. Therefore, an operational definition of falls is crucial along with explicit inclusion and exclusion criteria.

Most studies used a retrospective design and primarily focused on elderly population. Knowledge of the symptoms of hypoglycemia in this population is often poor. In addition, mild hypoglycemia remains unrecognized by patients, relatives, or healthcare providers. Moreover, underreporting and recall bias among elderly are other issues limiting the observational findings. The impact of hyperglycemia during hospitalization also needs to be addressed as it may alter the clinical picture through development of complications such as severe infection, cardiovascular emergencies, and acidosis. Despite high prevalence of DM (17%) and greater burden of road traffic accidents and fatalities in our region, there are only a few published studies that highlighted the impact of DM on the trauma.\(^7^9\)

CONCLUSIONS
DM poses significant burden as a risk factor for trauma and is considered a predictor of worse outcomes in traumatic injuries. Hypoglycemia is one of the major risk factors for traumatic injuries in DM patients. It is associated with inefficient driving performance due to compromised psychomotor skills, visuospatial functions, rapid information processing, vigilance, and satisfactory judgment. In addition, falls remain a major public health problem with significant morbidity and mortality, especially in the elderly population. In general, it is agreed that patients with DM are at increased risk for traumatic injuries (MVCs and falls) due to neurogenic (sweating, shakiness, tachycardia, anxiety, and sensation of hunger) and neuroglycopenic (weakness, tiredness, or dizziness; inappropriate behavior; confusion; and impaired vision and concentration) symptoms of hypoglycemia. Therefore, it is important to minimize the incidence of MVCs and falls in DM patients through education of health care professionals, public awareness, law enforcement, adopting newer technology (in-vehicle medical monitoring devices) and focuses injury prevention programs for geriatric population. Although there is no consensus on the impact of hyperglycemia in trauma patients as compared to the clear hazards of hypoglycemia, both extremes of diabetes need to be carefully addressed and managed. The unfavorable impact of hyperglycemia may be more evident during hospitalization. Moreover, physicians, patients, and authorities should be aware of all the potential risk and should contribute in establishing effective injury prevention strategies.

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41. Thank you for the question. Please provide me with more details about the specific content you would like to read naturally from the image.
Traffic hypoglycaemias and accidents in patients with Diabetes mellitus in patients presenting with Workplace-related traumatic injuries: Insights from a Journal of Emergencies, Trauma, and Shock I 9:2 I Apr - Jun 2016

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