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Elective Surgery in the Diabetic Patient: Hemoglobin A_{1C}

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Abstract: The prevalence and incidence of diabetes mellitus is rising in the United States. Physicians will increasingly be managing patients affected by this chronic endocrine disease. Recent literature has improved the characterization of the effect of long-term glycemic control on outcomes following foot and ankle surgery. The objective of this article is to review current available evidence and propose reasonable hemoglobin A_{1C} threshold parameters for elective surgery in the diabetic population.

Key words: Glycated hemoglobin, glycosylated hemoglobin, hemoglobin A_{1C}, HA_{1C}, diabetes mellitus

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The proportion of United States citizens diagnosed with diabetes mellitus has increased over the past two decades. The Center for Disease Control most recently estimated the age-adjusted percentage of adults with diabetes as 9.1% in 2015, compared with 4.4% in 1995.[1] Due to the increased prevalence of diabetes in the population and the propensity for these individuals to develop pedal complications, the American Diabetes Association recommends comprehensive diabetic foot examinations at least annually.[2] For the purpose of determining threshold values for elective surgery in this growing population, this article seeks to review relevant literature pertaining to the effect of hemoglobin A_{1C} (HA_{1C}) on outcomes after foot and ankle surgery.

Current Literature

A 2016 study by Domek et al. retrospectively reviewed 21,854 patients with diabetes who underwent elective foot and/or ankle surgery.[3] These authors recorded a 3.2% 30-day post-operative complication rate.[3] Infection was the most common complication (42.3%), followed by mechanical failure (33.4%), cardiovascular and/or pulmonary complications (18.4%), and lastly wound healing (5.8%).[3] The study found a statistically significant difference between the HA_{1C} of those patients with post-operative complication(s) and those without, although the mean HA_{1C} for those with complication(s) was only marginally higher at 6.29% than in the group without complication at 6.11%.[3] Notably, for each 1% increase in HA_{1C} the likelihood for post-operative complication increased 5%.[3]

The outcomes of 148 hindfoot and ankle arthrodeses were examined in a retrospective comparative study by Myers et al.[4] A minimum follow-up of 6-months was required for inclusion in the study.[4] For the 74 patients with diabetes (mean HA_{1C} 7.6%), the post-operative infection rate was 18.9% compared with 1.4% in the non-diabetic cohort.[4] The authors found that $HA_{1C} \geq 7\%$ conferred a 5.06-fold increased risk for post-operative infection among their study population.[4]

In 2014, Jupiter et al. published a retrospective review of 322 patients who had undergone foot and/or ankle surgery.[5] Procedures included in this study were elective or non-elective (including emergent) in

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nature.[5] The mean HA_{1C} for the reviewed population was 7.48% and the authors reported a 30-day post-operative complication rate of 28.88%.[5] The HA_{1C} at which the infection rate was found to increase was 7.35%.[5]

In the same year, Wukich et al. reported their level I prospective study of 2,060 patients undergoing elective or non-elective foot and/or ankle surgery.[6] Both patients with and without diabetes mellitus were included and an overall 30-day surgical site infection (SSI) rate of 3.1% was reported.[6] On analysis of the variables, both peripheral neuropathy and $HA_{1C} \geq 8\%$ were identified as independent risk factors for surgical site infection.[6] Those with $HA_{1C} \geq 8\%$ had a 2.7-fold increased risk for SSI compared to those with values below 8%.[6]

Recently, a retrospective comparative series of 4,630 diabetic patients who underwent elective forefoot surgery was published by Cancienne et al.[7] The authors reported a 1-year SSI rate of 3.73%. The authors included a longer surveillance period due to their suspicion for increased risk of delayed SSI secondary to impaired wound healing in diabetes and previous recommendations for 1-year surveillance after placement of orthopaedic implants.[7] The authors found that patients with a pre-operative $HA_{1C} \geq 7.5\%$ had more than a two-fold increased incidence of SSI, at 6.46%, compared with patients whose HA_{1C} was < 7.5%, at 2.80%.[7]

Risk factors for bone healing complications were investigated in a 2013 retrospective study by Shibuya et al.[8] 165 patients were reviewed who were diabetic and had undergone elective or non-elective foot and/or ankle surgery including osteotomy, arthrodesis, or reduction of fracture/dislocation.[8] In addition to elevated risk due to peripheral neuropathy and increased duration of surgery, $HA_{1C} > 7\%$ was associated with a 2.88-fold increased risk for delayed union, nonunion, or malunion.[8]

Discussion

Patients with diabetes mellitus are a challenging population with many variables affecting surgical planning and outcomes. In reference to elective surgery, Lavery stated in 2012 that "[a]t present, patient selection seems to rely on the ill-defined intuition of the surgeon."[9] Although this remains largely true today, further light has been shed on the impact HA_{1C} has on patients undergoing various types of foot and/or ankle surgeries.

To apply this recent data for planning elective surgery, it is important to recognize both patients' risk factors, such as elevated HA_{1C}, and the reason elective surgery is being considered. Sensate patients with diabetes may present with indications for elective procedures to address painful conditions, such as symptomatic deformity or degenerative joint disease. Others, typically those with neuropathy, may present with diabetic foot ulcers or pre-ulcerative lesions due to deformity or limited joint mobility, such as hallux limitus/rigidus or equinus. In 2003, Armstrong and Frykberg proposed a classification system for diabetic foot surgery based on patient characteristics and operative purpose.[10] According to this scheme, class I surgery is described as elective and consists of procedures "performed to alleviate pain or limitation of motion in a person without loss of protective sensation."[10] Class II, or prophylactic, surgery is "performed to reduce [the] risk of ulceration or re-ulceration in [patients] with loss of protective sensation" and intact skin.[10] Procedures "performed to assist in healing [an] open wound" are class III or curative.[10] Class IV, emergent, surgery is that which aims "to limit progression of acute infection."[10] For the purpose of this review, elective surgery includes the spectrum of classes I-III and no recommendations for class IV are made.

The ADA recommends the maintenance of HA_{1C} levels below 7.0% for most diabetic patients[2]. $HA_{1C} \geq 7.0\%$ is an appropriate contraindication to class I foot and/or ankle surgeries requiring bone healing, such as osteotomies and arthrodesis. Shibuya et all found a 3-fold increased risk for bone healing complications and Myers et al. found a 5-fold increased risk for infectious complications following hindfoot and ankle arthrodeses when HA_{1C} were elevated.[4,8] For class I surgery involving soft tissue only, an exclusionary threshold of $HA_{1C} \geq 7.5\%$ appears acceptable in light of the study by Cancienne et al. demonstrating a 2.80% incidence of SSI.[7]

The effectiveness of class II surgery for preventing initial ulceration in the diabetic foot has not been evaluated but it has been evaluated for the prevention of reulceration.[9] Armstrong et al. performed prophylactic lesser toe interphalangeal joint resectional arthroplasties in 64 patients with a mean 2.98-year follow-up, finding a 7.7% recurrence rate among patients with preceding ulceration.[12] The infection rate

for participants who had a history of pedal ulceration was 14.3% and 0% for those who did not have prior ulceration.[12]

Evidence for the effectiveness of class III surgery includes the facilitation of wound healing and low recurrence rates (around 5%) following hallux interphalangeal joint resectional arthroplasty (with a 9% infection rate) or first metatarsophalangeal joint (MTPJ) arthroplasty.[9] A study by Mueller et al. found lower foot ulcer recurrence rates with tendo Achilles lengthening (38%) compared with those treated via total contact casting (81%).[9] The recurrence rates of both class II and class III procedures compare favorably with the recurrence rates of diabetic foot ulcers that healed with non-operative therapy.[9] Furthermore, the study examining first MTPJ arthroplasty demonstrated an infection rate (40.0%) comparable with the non-operative therapy group (38.1%).[9]

Ulcerations presents an increased risk for infection, while wound recurrence rates are higher with non-operative treatment. Using a more lenient threshold of $HA_{1C} \geq 8\%$ to preclude patients from class II and class III elective foot and ankle surgery seems reasonable, given the 2.7-fold increased risk of SSI for patients above this value in the study by Wukich et al.[6] It should be noted that the average HA_{1C} for the aforementioned studies by Mueller, Armstrong, et al. were > 8%.[9,12] This suggests that an $HA_{1C} \geq 8\%$ for these surgical classes can probably be viewed as a relative, rather than absolute, contraindication to these types of procedures with careful consideration of these patients' individual circumstances and other risk factors for post-operative complications.

Conclusion

Recent literature has better characterized the effect of elevated HA_{1C} as an independent risk factor for bone healing and infectious complications after surgery. Based on current evidence, suggestions are made in this review for pre-operative threshold values for glycated hemoglobin based on a contemporary surgery classification. Specifically, $HA_{1C} \geq 7.0\%$ for class I osseous, $\geq 7.5\%$ for class I soft tissue, and $\geq 8.0\%$ for class II and III operations are proposed as threshold values contraindicating elective foot and ankle surgery.

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