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ORIGINAL RESEARCH

Preoperative ''NPO'' as an Opportunity for Diabetes Screening

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BACKGROUND: Novel preventive care opportunities, such as in hospitalized patients, may merit further investigation in an Accountable Care Organization (ACO) model. As 40% of patients with diabetes are undiagnosed, diabetes screening is an urgent public health need. Screening fasting preoperative patients may present an effective means to identify patients who might otherwise remain undiagnosed.

OBJECTIVE: To pilot an inpatient preventive care strategy for diabetes screening that would ascertain prevalence of unrecognized inpatient diabetes (DM) and impaired fasting glucose (IFG), determine reproducibility of preoperative fasting blood glucose (FBG), and establish feasibility of inpatient preventive screening.

DESIGN: Prospective observational study.

SETTING: Large Midwestern academic medical center.

PATIENTS: Two hundred seventy-five elective orthopedic patients with a preoperative visit between December 1, 2007 and November 30, 2008. Most patients (96.6%) had seen their primary care provider (PCP) within 12 months, and 100% were insured.

MEASUREMENTS: Medical history was recorded, and hemoglobin A_{1C} (Hgb A_{1C}) and FBG were drawn immediately prior to surgery. Patients with preoperative FBG $\geq$100 mg/dL had FBG drawn 6–8 weeks postoperatively.

RESULTS: Twenty-four percent (67/275) of patients had previously unrecognized DM or IFG by virtue of 2 abnormal values. Sixty-four percent of patients with FBG $\geq$100 mg/dL preoperatively remained elevated at ambulatory follow-up. No patients with new DM or IFG had point-of-care glucose checks ordered or had dysglycemia mentioned on discharge summary.

CONCLUSIONS: Inpatient undiagnosed DM and IFG is common, even in insured, elective surgery patients with recent primary care visits. Preoperative FBG can be used to screen, but results need to be conveyed to PCPs. *Journal of Hospital Medicine* 2012;7:611–616. © 2012 Society of Hospital Medicine

In the era of Accountable Care Organizations (ACO) and need to improve transitions of care, diagnosis and management of diseases across the continuum from ambulatory to inpatient care remains of paramount importance.[1,2] Opportunities for screening have typically been viewed as the responsibility of the ambulatory primary care provider (PCP), yet in an ACO model, patients who present more frequently to a hospital as opposed to a clinic are still the responsibility of the ACO, and therefore opportunistic screening for certain diseases by hospitalists and other inpatient providers is a possibility that may merit further investigation. This ''opportunistic'' rationale has already been used to advocate for pneumococcal and influenza vaccination prior to discharge in hospitalized patients, but has not been well investigated in chronic disease screening.[3–5]

Diabetes mellitus is a disease that has reached epidemic proportions. National Health and Nutrition Examination Survey (NHANES) data documented the ambulatory prevalence of diabetes mellitus (DM) in adults $\geq$20 years of age in the United States to be 12.9%.[6] However, the most significant health crisis may be that 40% of these adult patients with diabetes are unaware of their diagnosis.[6] In other words, 5.1% of all adults 20 years of age or older in this country have undiagnosed diabetes.[6,7] As diabetes is a disease where clinical manifestations are often preceded by a prolonged asymptomatic period, screening with either of the preferred diagnostic tests, fasting blood glucose (FBG) or hemoglobin A_{1C} (Hgb A_{1C}), is required to make a new diagnosis.[7–9]

Diagnosis of hyperglycemia is important so that appropriate glycemic control can be achieved, and preventive care and risk factor modification can be initiated, including screening and treatment of hypertension, hyperlipidemia, retinopathy, nephropathy, and other comorbid conditions.[7,9] As glycemic control cannot be achieved in patients who remain

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undiagnosed, screening may play a role in preventing long-term complications of diabetes.[7] Awareness of the prediabetic states impaired fasting glucose (IFG) and impaired glucose tolerance (IGT) is also important because lifestyle modification may delay or prevent the progression to diabetes and its associated complications, such as cardiovascular disease, retinopathy, and nephropathy.[10,11] In the inpatient setting, undiagnosed elevation of Hgb A_{1C} in the diabetes or prediabetes range has been shown to increase cost and length of stay in some spine surgery patients compared to patients with known diabetes.[12]

Virtually every inpatient has at least 1 glucose value drawn during hospitalization as part of a chemistry panel, many of which are fasting, or "NPO" ("nil per os", meaning nothing by mouth), by virtue of clinical condition or anticipated procedure. Provided the preoperative state in an elective surgery patient is not taxing enough to induce stress hyperglycemia,[13–15] this typically fasting time may provide an easy and excellent diabetes screening opportunity to not only risk stratify for the inpatient stay, but to diagnose diabetes that will initiate lifelong care and prevention, provided information learned during hospitalization is conveyed to the PCP at discharge. While prior studies[16–18] have measured preoperative glucose as a means to risk stratify and predict undiagnosed diabetes, none of these analyses have obtained a second glycemic test (either FBG or Hgb A_{1C}) as required by the American Diabetes Association (ADA) to make a diagnosis of diabetes. Lack of a confirmatory glycemic test in the existing literature also leaves uncertainty in reproducibility and validity of the preoperative glucose as a risk-stratification tool, as it is not certain that it is truly "unstressed." Finally, studies to date have not evaluated or controlled for factors that could contribute to undiagnosed diabetes, such as health insurance and access to primary care.

To investigate the prevalence of undiagnosed diabetes and prediabetes in a hospitalized population, and to pilot the concept of screening in the inpatient preoperative setting, we performed a prospective analysis of adult orthopedic patients presenting for elective hip, knee, and spine surgery at a large Midwestern academic medical center from December 1, 2007 to November 30, 2008. Our primary objective was to determine the feasibility of preoperative testing in finding the prevalence of undiagnosed diabetes and prediabetes in an insured, inpatient population with access to prior preventive care. In addition, we investigated systems issues related to the general concept of inpatient screening, including assessment of whether providers recognized hyperglycemic patients in the hospital once tested, or conveyed test information to PCPs at discharge.

METHODS

The University of Wisconsin Institutional Review Board approved this prospective observational cohort study. All patients aged ≥18 years scheduled for elective total knee or hip arthroplasty, or elective lumbar decompression and/or fusion, presenting for preoperative appointment from December 1, 2007 to November 30, 2008, were invited to participate. Pregnant patients, and patients unable to give consent were excluded. Patients with hemolytic processes or on new regimens of oral or intravenous steroids within 7 days of surgery were also excluded. Patients on chronic oral, inhaled, intranasal, or topical steroids were included.

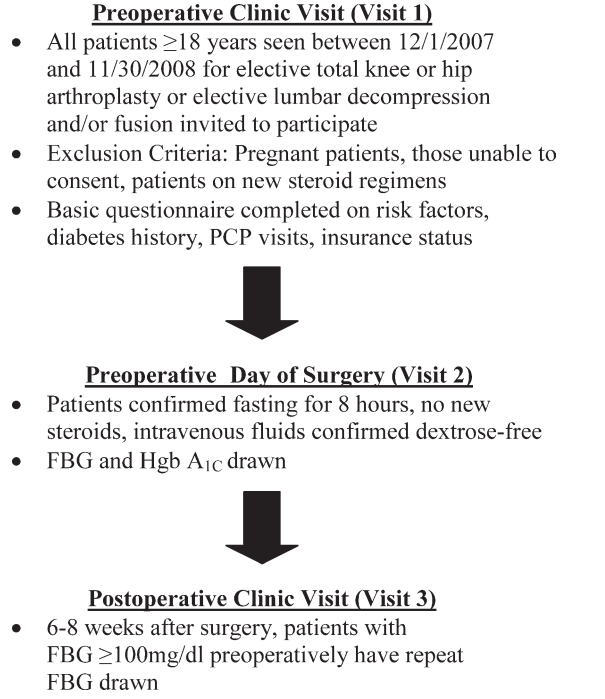

FIG. 1. Study protocol for Visits 1, 2, 3. Abbreviations: FBG, fasting blood glucose; Hgb A_{1C}, hemoglobin A_{1C}; PCP, primary care provider.

Preoperative Clinic Visit (Visit 1)

Patients who consented to participate had basic measures recorded, including height, weight, age, ethnicity, sex, date of surgery, and type of surgery. Patients then completed a questionnaire regarding previous history of diabetes and prediabetes (IFG or IGT), and personal history of other ADA-designated risk factors[9] to prompt diabetes screening, including gestational diabetes, hypertension, hyperlipidemia, vascular disease, and physical inactivity, as measured by the University of California, Los Angeles (UCLA) score.[19] Patient self-reported diagnosis of DM or prediabetes was compared to anesthesia preoperative assessment for confirmation. Finally, insurance status and most recent visit to a PCP were recorded (Figure 1).

Preoperative Day of Surgery (Visit 2)

On the morning of surgery, the study coordinator met with patients in the preoperative unit to confirm fasting status (nothing to eat for 8 or more hours), no new intravenous or oral steroids, and that intravenous

fluids were dextrose free. Fasting blood glucose was collected as whole blood and centrifuged in the central laboratory, after which plasma glucose was measured using the hexokinase method (Siemens Dimension Vista 3000T, Siemens Healthcare Diagnostics, Inc, Newark, DE). Hemoglobin A_{1C} (Tosoh G7 HPLC, Tosoh Bioscience, Tokyo, Japan) was also obtained. Patients with preoperative FBG $\geq$100 mg/dL were notified and scheduled to return for another FBG measurement at their 6–8 week orthopedic ambulatory clinic follow-up visit.

Postoperative Clinic Visit (Visit 3)

At 6–8 week follow-up, patients with preoperative FBG $\geq$100 mg/dL had an additional FBG performed. Those who also had a follow-up FBG $\geq$100 mg/dL at Visit 3 were determined to have DM or IFG, identified as New Diabetes/Prediabetes. Patients with glucose $\geq$100 mg/dL prior to surgery that was $<$100 mg/dL in follow-up, as well as patients with blood glucose $<$100 mg/dL at preoperative Visit 2 (and therefore did not require a follow-up glucose measurement) were designated Normoglycemia. Patients with preexisting DM or IFG were labeled Known Diabetes/Prediabetes.

Statistical Methods

Categorical variables were summarized using percents. Continuous variables were summarized using means and standard deviations. Chi-square tests were conducted for categorical variables and Student *t* tests were used for continuous variables to compare differences between patients with newly diagnosed IFG or DM (New Diabetes/Prediabetes) and patients without diabetes (Normoglycemia), and to compare differences between patients with New Diabetes/Prediabetes and patients with known DM or IFG (Known Diabetes/Prediabetes). Sample size was determined by number of adult elective spine and total joint orthopedic patients presenting to clinic during the prespecified 1-year period of time. All tests were considered significant if P value < 0.05.

RESULTS

A total of 302 patients met inclusion criteria and enrolled in the study. Of these patients, 27 (8.9%) were not included in final analysis due to incomplete preoperative labs (7 patients, 2.3%), lack of follow-up (11 patients, 3.6%), withdrawal of consent (5 patients, 1.7%), or not having surgery (4 patients, 1.3%). Of the remaining 275, 54% were female. The mean patient age was 60.3 years, and 88% (243/275) of patients had a body mass index (BMI) $\geq$25 kg/m^2, indicating overweight or obese. All of the patients (100%) had healthcare insurance; 97% reported having a primary care provider, with 96.6% of patients stating that they had seen a primary provider within the year prior to surgery (Table 1).

TABLE 1. Baseline Characteristics (N = 275)

	No. (%)
Demographics	
Female	148 (54)
Age, mean (SD)	60.3 (11.3)
BMI, mean (SD)	31.16 (5.93)
Surgery type	
Hip	99 (36)
Knee	147 (53)
Spine	29 (11)
Socioeconomic status/healthcare access	
Have healthcare insurance*	274 (100)
Have regular PCP	267 (97)
Last PCP visit†	
Never	2 (0.7)
>3 y	1 (0.4)
1–3 y	6 (2.2)
6 mo–1 y	18 (6.6)
<6 mo	244 (90)
Medical history	
Diabetes history	
No history of dysglycemia	225 (82)
Prior IFG	17 (6)
Prior DM	33 (12)
American Diabetes Association risk factors	
BMI $\geq$25	243 (88)
Physical inactivity (UCLA score $\leq$3)	40 (18)
High risk ethnicity	3 (1)
Gestational DM	2 (1)
First degree family history	91 (33)
Cardiac disease	35 (13)
Hypertension	127 (46)
Hypercholesterolemia	114 (42)
Prior IFG/IGT	19 (7)
Age $\geq$45 y	249 (91)

Abbreviations: BMI, body mass index; DM, diabetes mellitus; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; PCP, primary care provider; SD, standard deviation; UCLA score, activity score of the University of California, Los Angeles. * One patient omitted answer. † Four patients omitted answer.

Of the 275 patients, 50 (18%) had Known Diabetes/Prediabetes, 67 (24%) were given a new diagnosis of DM or IFG (New Diabetes/Prediabetes), and the remaining 158 (58%) were classified as Normoglycemia (Table 2). The sum of Known Diabetes/Prediabetes (50) and New Diabetes/Prediabetes (67) equaled the true inpatient prevalence of DM and IFG (117/275, 43%). Of the Known Diabetes/Prediabetes patients, 33/50 (66%) had DM and 17/50 (34%) had IFG. Of those with New Diabetes/Prediabetes, 8/67 (12%) had DM range values, with the remaining 59/67 (88%) in IFG range.

Patients with New Diabetes/Prediabetes had a higher preoperative Visit 2 glucose (mean [standard deviation], 110.79 [8.69] and 96.04 [9.10], $P < 0.0001$) and Hgb A_{1C} (5.80 [0.39] and 5.45 [0.36], $P < 0.0001$) compared to Normoglycemia. A subset of the Normoglycemia patients (38/158, 24%), had an elevated preoperative Visit 2 glucose, but a normal ($<$100 mg/dL) second confirmatory Visit 3 glucose, and therefore did not have New Diabetes/Prediabetes. New Diabetes/Prediabetes was also significantly

TABLE 2. Diagnosis by Glucose Value (N = 275)

Diagnosis	No. (%)	Hemoglobin A_{1C} (Mean, SD)	Preoperative Glucose (Mean, SD)	Follow-up Glucose (Mean, SD)	Days Between (Mean, SD)
Known diabetes/prediabetes	50 (18)	6.53 (0.99)	129.02 (33.85)		
New diabetes/prediabetes*	67 (24)	5.80 (0.39)†	110.79 (8.69)†	107.91 (7.47)‡	51.67 (13.73)§
Normoglycemia	158 (58)	5.45 (0.36)†	96.04 (9.10)†		
Preop glucose ≥100, follow-up <100	38 (14)	5.54 (0.35)	107.26 (8.69)	93.68 (5.16)‡	49.21 (12.11)§
Preop glucose <100	120 (44)	5.42 (0.36)	92.49 (5.73)		

NOTE: Patients with known history of diabetes or impaired fasting glucose, or normal preoperative glucose did not have follow-up glucose testing. **Abbreviations:** SD, standard deviation. * Preoperative glucose ≥100, follow-up ambulatory value also ≥100. † *P* values significant at <0.05 when New diabetes/prediabetes is compared to Normoglycemia. ‡ *P* values significant at <0.05 when New diabetes/prediabetes is compared to Preop glucose ≥100, follow-up <100. § Days Between represents days elapsed between preoperative and follow-up glucose draws.

different from this particular Normoglycemia subset in both FBG (110.79 [8.69] and 107.26 [8.69], $P = 0.048$) and Hgb A_{1C} (5.80 [0.39] and 5.54 [0.35], $P = 0.001$) (Table 2). Preoperative Visit 2 FBG of ≥100 mg/dL predicted Visit 3 FBG ≥100 mg/dL 64% of the time. Having both preoperative Visit 2 FBG ≥100 mg/dL and Hgb A_{1C} ≥5.7 (the ADA-determined level for prediabetes),[3] predicted Visit 3 FBG ≥100 mg/dL 72% of the time.

Patients with New Diabetes/Prediabetes were slightly older than Normoglycemia patients (62.37 [9.70] vs 58.08 [12.01], $P = 0.0054$), meeting the ADA diabetes screening age of 45 significantly more often than Normoglycemia patients (100% [67] vs 84% [132], $P < 0.001$). The groups otherwise did not differ in the incidence of other ADA-defined risk factors[9] (Table 3). Patients with New Diabetes/Prediabetes were less likely to report having seen their PCP within 6 months prior to surgery compared to their Normoglycemia counterparts (82% [54] vs 91% [141], $P = 0.046$), although this difference disappeared by 1 year (94% vs 96%). Finally, there was no increase in the number of point-of-care (POC) glucose tests ordered, or mention of hyperglycemia on discharge summaries in the New Diabetes/Prediabetes group (Table 3).

TABLE 3. Patient Characteristics by Diagnosis

Demographics	Normoglycemia (N = 158)	New Diabetes/ Prediabetes (N = 67)	Known Diabetes/ Prediabetes (N = 50)
Female	90 (57)	33 (49)	25 (50)
Age, mean (SD)	58.08 (12.01)*	62.37 (9.70)	64.60 (9.02)
BMI, mean (SD)	30.13 (5.76)	31.65 (5.76)	33.74 (5.92)
Surgery type			
Hip	62 (39)	21 (31)	16 (32)
Knee	76 (48)	41 (61)	30 (60)
Spine	20 (13)	5 (7)	4 (8)
Socioeconomic status/healthcare access			
Have healthcare insurance	158 (100)	66 (100)	50 (100)
Have regular PCP	153 (97)	65 (98)	49 (98)
Last PCP Visit			
Never	2 (1)	0 (0)	0 (0)
>3 y	1 (1)	0 (0)	0 (0)
1–3 y	1 (1)	4 (6)	1 (2)
6 mo–1 y	10 (6)	8 (12)	0 (0)
In last 6 mo	141 (91)*	54 (82)	49 (98)†
Medical history			
American Diabetes Association risk factors			
BMI ≥25	133 (84)	62 (93)	48 (96)
Physical inactivity (UCLA score ≤3)	16 (13)	10 (18)	14 (35)
High-risk ethnicity	2 (1)	1 (1)	1 (2)
Gestational diabetes	1 (1)	1 (1)	0 (0)
First degree family history	45 (28)	19 (28)	27 (55)†
Cardiac disease	14 (9)	7 (10)	14 (28)†
Hypertension	62 (39)	31 (46)	34 (68)†
Hyperlipidemia	54 (34)	28 (42)	32 (64)†
Age ≥45	132 (84)*	67 (100)	50 (100)
Follow-up			
Point-of-care glucose ordered	1 (1)	0 (0)	31 (62)†
Dysglycemia mentioned on discharge summary	0 (0)	0 (0)	28 (56)†

NOTE: All values are No. (%) unless otherwise specified. **Abbreviations:** BMI, body mass index; PCP, primary care provider; SD, standard deviation; UCLA score, activity score of the University of California, Los Angeles. *$P < 0.05$ for Normoglycemia vs New Diabetes/Prediabetes. †$P < 0.05$ for New Diabetes/Prediabetes vs Known Diabetes/Prediabetes.

DISCUSSION AND CONCLUSION

The main finding of this study is that in an insured, elective orthopedic population with access to primary care, 24% of patients had unrecognized IFG or DM on the basis of 2 fasting blood glucose values. Remarkably, this statistic likely represents a ''best-case scenario,'' as the percent of undiagnosed patients is likely higher in uninsured patients,[20] those without primary care visits, and those hospitalized for emergent or urgent reasons who, by definition, did not have an ambulatory preoperative evaluation, and who may also have greater severity of illness at baseline. With over 1,053,000 total knee and hip operations done in the United States each year, opportunistic screening of this population alone could identify 252,720 patients with prediabetes or diabetes who might otherwise remain undiagnosed.[21] Even more significant, with at least 70 million patients undergoing ambulatory or inpatient procedures each year, if even a quarter of these procedures were elective adult lower acuity surgeries allowing for easy preoperative testing, over 4 million cases of DM and IFG could be found each year using this process.[21,22] These numbers demonstrate the need to investigate new and novel screening opportunities, such as in hospitalized patients. These statistics also demonstrate the need for all inpatient providers to be aware of undiagnosed diabetes and prediabetes in their patients, and confirm

recommendations of the Endocrine Society to obtain a blood glucose for all patients on admission, and measure Hgb A_{1C} in all hyperglycemic or diabetic inpatients if not performed in the preceding 2–3 months.[23]

Diagnosis of DM has historically been difficult to make in the hospital setting. The primary diagnostic test, FBG, may be elevated in the setting of counter-regulatory hormone surge and inflammatory stress response, and its use has been discouraged in the acute care setting.[14,15,24] While not affected by stress, Hgb A_{1C}, endorsed in 2010 by the ADA for diagnosis of DM,[8] may still be unreliable in the setting of blood loss, transfusion, hemolysis, and other factors common during surgery and hospitalization.[9,25] However, we found that 64% of patients with elevated ($\geq$100 mg/dL) blood glucose at the time of pre-anesthesia evaluation did have persistently elevated blood glucose at 6–8 week follow-up. This suggests that the preoperative glucose is ''unstressed,'' and may be a rapid, reasonably reliable indicator of patients needing ambulatory follow-up to confirm DM or prediabetes. This may also provide perioperative risk stratification if glycemic history is unknown. As many fasting, preoperative patients have routine chemistry panels ordered already, the simple glucose included in such panels may prove to be the most useful diabetes test for anesthesiologists, surgeons, hospitalists, and other inpatient providers. Our data suggests that Hgb $A_{1C} \geq 5.7$, the ADA-suggested IFG/prediabetes cut point,[9] can also be used in combination with FBG $\geq$100 to predict persistent hyperglycemia.

This study also revealed several significant systems issues that merit attention if opportunistic inpatient screening or preventive care is to be successful in a shared responsibility ACO system. Most importantly, none of our patients with elevated preoperative blood glucose had these results conveyed to their primary care provider at discharge, revealing both a need for improved transitions in care and development of formal ACO structure if inpatient or preoperative screening is to be successful. Second, our study also showed that providers did not change plan of care for patients without known DM or IFG and preoperative elevated glucose. None of these patients had point-of-care glucose checks ordered while in the hospital, demonstrating that previously undiagnosed dysglycemic patients receive different in-hospital care compared to patients with known DM. While it is possible that providers consciously decided not to monitor patients with mild hyperglycemia, consistent with inpatient guidelines recommending glycemic targets of <180 mg/dL for general care patients,[20] it is more likely that there was lack of recognition of hyperglycemia in these patients without prior DM or IFG, as has been demonstrated previously.[26] Inpatient providers should be informed of, and encouraged to, follow Endocrine Society recommendations to monitor POC glucose in patients with hyperglycemia (>140 mg/dL) for at least 24–48 hours.[23]

It is important to state that controversy exists regarding which patients should be screened for diabetes. The United States Preventive Services Task Force (USPSTF) recommends screening adult patients only if they have hypertension.[27] The ADA recommends screening all patients 45 years of age and older, and younger, overweight patients with at least 1 additional risk factor.[9] We have previously shown that using USPSTF guidelines misses 33.1% of cases of DM compared to the ADA standard.[28] As such, our institution and the Wisconsin State Diabetes Screening Guidelines mirror the ADA guidelines.[29,30] In the present study, 91% were aged 45 and older, and 88% were overweight, so nearly everyone in our study met our state and institution guidelines for diabetes screening. However, this might not be the case at all institutions if USPSTF guidelines were instead followed.

A limitation of the present study was that a selection bias of subjects could have occurred by both patients and providers, as less healthy patients with higher surgical risk may not have been candidates for surgery as often as lower-risk patients. While entirely appropriate to maximize safety for elective surgery patients, this may in part explain the lower Hgb A_{1C} (6.53 [0.14]) in our Known Diabetes/Prediabetes group, and lower range of blood glucose values in our New Diabetes/Prediabetes patients, with the majority being in the prediabetes range. However, this limitation also allows for the conclusion that any patient, regardless of perceived good health and primary care visits, may still have undiagnosed DM or IFG.

In summary, this study strongly supports the practice of screening obligate fasting patients to reduce the prevalence of undiagnosed diabetes. Despite the fact that our patients had insurance and recent primary care visits, nearly one-quarter of individuals had previously unrecognized dysglycemia. This study also revealed systems issues, including the need for improved care transitions and development of a structure for shared responsibility in an ACO system, that need to be addressed if screening initiatives are to be effective in the hospital setting. Future studies will be needed to determine if other ''opportunistic'' screening tests have case-finding potential, and further, how transitions processes can be improved to ensure that knowledge gained in the hospital is conveyed to the ambulatory setting.

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