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PERSPECTIVE

Wearable activity trackers and mobilization after major head and neck cancer surgery: you can't improve what you don't measure

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Abstract

Major surgery involving resection and free flap reconstruction is a mainstay of head and neck cancer (HNC) treatment, but postoperative morbidity and complications are common. One of the foundations for better surgical outcomes is early mobilization, which is included in enhanced recovery guidelines for all surgical specialties. However, a major unsolved challenge with early mobilization after surgery is quantifying how much a patient moves. To date, mobilization after major HNC surgery has been reported as the time to mobilization, i.e. the interval between the date of surgery and the date of the initial meaningful mobilization. Other data on postoperative mobilization in these patients are limited. Although clinicians can document mobilization via multidisciplinary progress notes, an estimate of mobilization for each postoperative day would be subjective and based on observations from several clinicians and/or the recall of the patient. Advancing research on postoperative mobilization requires the ability to objectively measure patient activity, particularly ambulatory activity, without placing a further burden on the inpatient team. Wearable activity trackers may provide a solution. Data from other surgical specialties indicate that such objective monitoring of patient ambulation in real-time to support interventions to increase mobilization may provide opportunities to improve clinical care. Objective measurement of step counts after HNC surgery would lead to an understanding of the dose-response relationship (the required quantity and frequency of mobilization that is safe and beneficial). In conclusion, the integration of wearable activity trackers in the care plan for patients undergoing HNC surgery will facilitate the measurement and improvement of postoperative mobilization to reduce complications, improve surgical outcomes and enhance patient recovery.

Keywords: head and neck cancer, surgery, mobilization, wearable technology

1. Introduction

Cancers of the head and neck are amongst the top ten most common cancers worldwide¹. Major surgery involving resection and free flap reconstruction is a mainstay of head and neck cancer (HNC) treatment, but postoperative morbidity and complications are common. Two-thirds of patients will have at least one surgical or medical complication, with most occurring on postoperative day (POD) 1-4². To ensure the best possible patient outcomes, evidence-based HNC-specific enhanced recovery pathways (ERPs) that detail perioperative care processes and timelines have been implemented³⁻⁵. The goals of ERPs are to improve the quality of care and fast-track postoperative recovery. One of the foundations for better surgical outcomes is early mobilization, which is included in enhanced recovery guidelines for all surgical specialties⁶. However, a major unsolved challenge with early mobilization after surgery is quantifying how much a patient moves. Advancing research on postoperative mobilization requires the ability to objectively measure patient activity, and wearable technology may provide the solution. This perspective article will describe the measurement and benefits of postoperative mobilization after HNC surgery and discuss how wearable activity trackers (WATs) can be used to improve surgical outcomes for patients.

2. Early mobilization after head and neck cancer surgery

2.1 Evidence of benefit

Early mobilization after surgery includes activities such as sitting, standing, and walking, typically, within the first 48 h. However, the specific activity and timeframe (i.e. the definition of early mobilization) can differ between contexts and surgical pathways. Still, after HNC surgery, it is strongly recommended that patients are mobilized within 24 hours if possible⁵. Established and long-term HNC ERPs have shown consistent reductions in the time to mobilization that occurred alongside a reduction in pulmonary complications and hospital length of stay (LOS)^{4,7}. Unfortunately, evidence for an association between improved mobilization and better outcomes is limited because early mobilization is only a single care element within an ERP incorporating many care elements. Few papers provide evidence for the independent contribution of early mobilization to improved clinical outcomes, but those that do are promising. In one retrospective cohort study, delayed mobilization was found to be an independent risk factor for postoperative pneumonia⁸. Patients who had not been mobilized by POD 4 were more than four times more likely to develop the infection. Furthermore, in one randomized trial of an early mobilization protocol, the intervention group had shortened time to removal of the nasogastric tube, urethral catheter and tracheotomy, longer sleep time and better patient comfort⁹. Traditionally, surgeons may have

recommended bed rest or activity restrictions due to a perceived increased risk of vascular flap failure with mobilization. Although the evidence of benefit for specific early mobilization protocols in HNC surgery is somewhat limited, both studies demonstrated that early mobilization does not increase the risk of such surgical complications^{8,9}.

2.2 Current measurement and limitations

To date, mobilization after major HNC surgery has been reported as the time to mobilization, i.e. the interval between the date of surgery and the date of the initial meaningful mobilization^{4,8}. In the Calgary Head and Neck Enhanced Recovery Program, the median time to mobilization has improved to 2 days (interquartile range 1-3 days)⁴. A dedicated research nurse collects mobilization data from the hospital electronic health record, which records when the patient was out of bed/up in chair/ambulatory. Therefore, the current measurement of mobilization time relies on accurate and consistent charting by the healthcare team within the context of a busy clinical workflow. Although any data on mobilization is valuable, a single metric such as time to mobilization cannot provide a comprehensive assessment of mobilization across the inpatient period. Guidelines for measuring the frequency/quantity of mobilization within HNC ERPs vary but can include: duration of hours per day out of bed and moving⁴, distance walked per day or number of walks greater than 30 meters per day⁹. Clinical teams need to agree on a consistent set of mobilization measures and then use them consistently. There is a large variation between patients in their ability to mobilize while still complying with activity guidelines. Although clinicians can document mobilization via multidisciplinary progress notes, an estimate of mobilization for each POD would be subjective and based on observations from several clinicians and/or the recall of the patient. Aside from issues with accuracy, this assessment also places an undue burden on the clinical team. Moreover, the validity of these data for research on mobilization and patient recovery is unclear. Therefore, despite its role in patient recovery after surgery, the measurement of postoperative mobilization after HNC surgery is not accurate, reliable or replicable.

3. Towards a better understanding of mobilization after head and neck cancer surgery

3.1 The dose-response relationship

Objective measurement of mobilization after HNC surgery would lead to an understanding of the dose-response relationship (the required quantity and frequency of mobilization that is safe and beneficial). High-resolution mobilization data would inform more specific recommendations for individual patients

and identify those patients who are moving less than expected. Poorly mobilizing patients would then receive enhanced care to determine factors causing diminished activity (e.g. pain, nausea, other limitations). This level of granularity would allow for real-time recovery (targeting the right patients at the right time) by anticipating which patients might most benefit from intervention before they deteriorate¹⁰. Further, understanding the dose-response relationship would aid in the development and assessment of interventions designed to improve recovery. As a minimum, an intervention could include self-monitoring of activity and goal-oriented feedback to the patient, in collaboration with their healthcare team, to reduce LOS and morbidity, and improve quality of life.

3.2 Physical activity across the inpatient period

In addition to mobilization in the first 48 h after surgery, measuring and increasing physical activity during the hospital stay (typically 10-14 days after major HNC surgery) is important for several reasons. Physical activity, defined as any bodily movement produced by skeletal muscles that results in energy expenditure¹¹, prevents the cardiorespiratory and muscular deconditioning that can occur after surgery. An abrupt and acute reduction in physical activity during the inpatient period is not benign, particularly in combination with inflammation and other homeostatic disruptions caused by major surgery¹². It is well understood that not only bed rest but also a less drastic reduction in ambulation results in metabolic alterations and loss of muscle mass and function that is more pronounced in older adults¹³⁻¹⁵. Muscle disuse can accelerate sarcopenia¹⁶, and this is especially problematic considering many patients with HNC will go on to have adjuvant chemoradiation and be at further risk of loss of muscle mass and function due to malnutrition and cancer cachexia¹⁷. To combat this, a graded increase in physical activity can be prescribed as an increase in walking for most patients after HNC surgery. The transition to unaided walking during the hospital stay promotes a return to a level of independence and sets the stage for a more seamless transition to recovery at home. Indeed, there is growing evidence to suggest that the quantity of inpatient ambulation may be linked to important clinical outcomes¹⁸.

In summary, advancing research on postoperative mobilization requires the ability to objectively measure patient activity, particularly ambulatory activity, without placing a further burden on the inpatient team. Wearable technology may provide a solution.

4. Wearable activity trackers for the measurement of perioperative mobilization

4.1 Introduction

WATs are small devices worn close to the body to provide accelerometry-derived information on physical activity (e.g. activity counts, step counts, distance) and may also incorporate other biosensors (e.g. optical heart rate monitors, gyroscope). 'Research-grade' WATs are those that have been thoroughly evaluated for precision and accuracy¹⁹, and are designed to store all data on the device itself²⁰ (e.g., the ActiGraph). Consumer-level WATs exchange information wirelessly via Wi-Fi or Bluetooth to a smartphone or centralized database. New consumer-level WATs (e.g., models by Fitbit and Garmin) are released regularly and now include relatively inexpensive and unobtrusive wrist-worn devices that display real-time feedback, paired with user-friendly smartphone applications displaying summary information. The distinction between research and consumer-level WATs is becoming blurred – the cost, user experience and low burden associated with consumer-level devices mean that they are increasingly incorporated into health research and medicine²¹. A major benefit of WATs in healthcare settings is that they can provide a continuous and objective measurement of physical activity without direct observation of the patient. However, consumer WATs do not provide a gold-standard measurement of physical activity (or energy expenditure). Still, they can provide accurate measures of steps for structured ambulatory activity²², and the inter-device reliability of step count is generally high²³.

Step count is a simple and easy-to-understand metric, and real-time feedback of steps may serve as a motivator for patients to move more in hospital. Despite some limitations (see *Section 5*), as part of patient-centred care, WATs may increase the patient's involvement in and sense of control over an important aspect of their recovery. Another benefit of using step count from a WAT is that a modest daily step goal can be achievable for even the most inactive patients, whose pre-operative activity level may have been only basic ambulatory activities²⁴.

4.2 Existing evidence

Several studies have included interventions using WATs during hospitalization for an acute medical/surgical condition²⁵. To date, no studies have used a WAT to measure or increase mobilization after HNC surgery, but there are examples in other surgical specialties. For example, after eight major surgical procedures, a higher step count on POD 1 was associated with a decreased probability of a prolonged LOS, and the WAT provided a more accurate assessment of mobilization than estimates from the patient's surgeon¹⁸. After resection of peritoneal cancer, a higher mean daily step count during the

inpatient period predicted a lower risk of hospital readmission²⁶. After liver resection, real-time monitoring of activity during an early mobilization protocol resulted in increased steps, less pain and a shorter LOS²⁷. Finally, after laparoscopic surgery, patients who received continuous feedback of steps increased their activity time, and patients with a higher step count had a shorter LOS and lower morbidity²⁸. These findings indicate that monitoring of perioperative mobility using WATs may identify patients at risk for poor postoperative outcomes and that real-time feedback from WATs in combination with early mobilization strategies may improve postoperative outcomes. This evidence should now be applied to patients undergoing surgery for HNC.

5. User experience and accuracy

There are several considerations regarding the choice of WAT that relate to user experience and data accuracy. Patients are generally positive about WATs, but the complexity of the WAT, doubts about its validity, and lack of clear instructions are some possible patient barriers²⁹. To both patients and the clinical team, expectations about how the WAT should be used must be clearly communicated²⁴. Patients need support to set up the device, sync and interpret the data, but in general, WATs are perceived as acceptable and useful³⁰⁻³². User experience for clinicians is also important, and integration of the WAT data in the electronic health record will reduce the need for clinician assessment, manual data entry and to allow for real-time feedback and remote monitoring of postoperative mobilization^{18,33}.

The algorithms for step counts in consumer-level WATs are generally as accurate as research-grade WATs^{23,34}. However, the validity of data can vary based on the specific model. It was recently reported that only 5% of commercially-available wearable technologies had been formally validated, and only ~10% have been developed specifically for research purposes³⁵. WATs that have been developed based on real-world needs and are regularly used in research, but lack rigorous independent validation, should be considered as "well-supported" and used with caution³⁵. One reason for caution is that the accuracy of WATs can depend on the placement and speed of ambulation. For some devices, step count accuracy might be reduced at slow walking speeds ($2 \text{ km} \cdot \text{h}^{-1}$)^{36,37}, and this should be checked for individual devices (compared with criterion measures, e.g., manual step count) before implementation. Ankle placement may be the solution if the device does not detect every step for altered and slow walking patterns³⁸ (which is likely in the early PODs after HNC surgery and for elderly patients). However, the caveat is that the proprietary algorithms used to calculate step count with wrist placement may not function optimally with

ankle placement. Researchers should also account for some missing data when using WATs due to device malfunction or issues with data collection, and this can range from 2-33% during hospitalization²⁵. There are several tips for improving the off-the-shelf accuracy of consumer devices, including having patients wear the WAT in the same position each day, and for wrist-worn trackers, indicating if the patient is wearing it on the dominant or non-dominant side within the software²³. Nevertheless, with consideration of the margin of error, measurement of steps with WATs can provide an objective measurement of postoperative mobilization that is far superior to current methods.

At present, consumer-level WAT companies (e.g. Fitbit, Garmin) provide users with a subset of the data that are collected. It is not always possible to export the raw data, and data algorithms are not shared with researchers. This situation is at odds with the transparency required when describing the data processing and analysis used in a scientific study. In addition, there are considerations regarding the protection of personal information and patient data with the use of WATs and smartphone applications³⁹. For example, the company that sells the WAT owns the data rather than the owner of the device, and data can be sold to third-party agencies⁴⁰. There is a move towards open-source software frameworks for wearable technology as applied to health research²⁰, but for most consumer WATs, data access, privacy, and informed consent should be considered and discussed with institutional ethics boards⁴¹.

6. Introducing wearable activity trackers to an enhanced recovery pathway for head and neck cancer

We have recently conducted a feasibility study^{30,42} within the Calgary Head and Neck Enhanced Recovery Program^{4,43} to add WATs to the postoperative period. A wrist-worn WAT (Garmin vívofit®4) was provided on POD 1 following major HNC surgery with free flap reconstruction. Once the patient arrived on the unit from the ICU, the WAT was positioned on the patients' non-dominant or non-donor wrist (in the case of a radial forearm free flap) by the inpatient team. A few key lessons were learned during the implementation of the new workflow related to the WAT.

6.1 Communication with the inpatient team

Regular and ongoing communication with and meaningful involvement of the inpatient team is essential. This includes meeting with nurse educators and unit managers to consider workflow implications and explaining the purpose of the WAT during nursing huddles. Successful implementation of WATs can be

improved by involving a research assistant or local champion to help troubleshoot early issues, and regular reminders can ensure data collection in the context of other busy workflows.

6.2 Education and the need for future tailoring

Patients should be empowered by including a dedicated introduction to the importance of postoperative mobilization and how the WAT can facilitate this. Due to wide variations in total daily step count after surgery (which could in part be due to factors such as differences in symptoms and limitations experienced), step count prescriptions should be tailored to the individual, alongside core messaging such as "try to walk more than you did yesterday," and "try to avoid prolonged periods of inactivity during the day."

6.3 WAT placement

Many patients use a walking aid (walking frame with arm support) for at least part of their stay on the hospital unit (typically on POD 1-3) and, at other times, patients walk with an intravenous pole. One solution is to move the WAT to the ankle (non-donor limb, in the case of a fibula free flap) with the use of a strap extender for the days that a walking aid was being used (see Section 5 for accuracy considerations).

7. Additional avenues of research using wearable activity trackers for patients undergoing surgery for head and neck cancer

Although our focus has been on the use of WATs for measurement of ambulation as a cornerstone of mobilization, other studies have used research-grade devices to measure time spent supine, sitting, and standing^{44,45}, and these measures may also be relevant after HNC surgery as a measurement of sedentary behaviour. Another major avenue for future research in HNC is the use of WATs preoperatively, where step count might provide a marker of surgical risk. For example, low pre-operative physical activity (<5000 steps per day) after colorectal surgery was found to be a significant independent predictor of poor surgical outcomes⁴⁶. Similarly, in older adults, a step count <2500 steps per day was associated with a longer LOS and was an independent predictor of serious complications⁴⁷. Extending the measurement of mobilization to the pre-operative period allows investigation of the predictive power of physical activity/inactivity on clinically relevant outcomes such as the risk of complications, which may inform future interventions. It has previously been suggested that exercise physiologists could take on the role of

early and progressive mobility specialists who reduces the burden on physical therapists and nurses⁴⁸. An intervention supported by clinical exercise physiologists may be important in implementing tailored recommendations for physical activity, which is especially relevant for prehabilitation⁴⁹. Objective measurement of physical activity via WATs before HNC surgery will enable remote monitoring of prehabilitation interventions (which extends to the use of a WAT across the pre and postoperative phases).

8. Conclusion

Early mobilization is a mainstay of enhanced recovery after surgery, including in HNC. However, aside from time to the first mobilization, data on postoperative mobilization in patients undergoing HNC surgery with free flap reconstruction are limited. Data from other surgical specialties indicate that objective monitoring of patient ambulation in real-time to support interventions to increase the quantity and frequency of mobilization may provide opportunities to improve clinical care without undue burden to patients or the inpatient team. The integration of WATs in the care plan for patients undergoing HNC surgery will facilitate the measurement and improvement of postoperative mobilization to reduce complications, improve surgical outcomes and enhance patient recovery.

Conflict of Interest Statement

None

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Rosie Twomey: Conceptualization, Writing - Original Draft. S. Nicole Culos Reed: Writing - Reviewing and Editing. Julia T. Daun: Writing- Reviewing and Editing. Reed Ferber: Writing- Reviewing and Editing. Joseph C. Dort: Conceptualization, Writing - Reviewing and Editing, Supervision.

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