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Master thesis | Original study

Safety and follow-up systems after ambulatory peripheral nerve block: a narrative review

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Abstract

Background: **Ambulatory surgery has grown during the last decades, and Peripheral Nerve Blocks (PNB) are widely used for perioperative and postoperative pain management. Follow-up is required during all stages of recovery to assess adverse events. Patients are usually discharged before PNB effects have worn off, but next-day follow-up allows the detection of adverse events. Digital systems are used for different follow-up services, but knowledge is lacking in their use for PNB follow-up.**
Objective: **This narrative review describes PNB-related adverse events and current ambulatory surgery follow-up practices during all recovery stages. Furthermore, this review will evaluate the methods used for PNB follow-up.**
Methods: **A literature search was performed using SCOPUS, Embase, and MEDLINE databases from the earliest record to 01-03-2022. Articles were included if they assessed PNB-related adverse events, follow-up services for ambulatory surgery and PNBs, and outcomes for ambulatory surgery and PNBs. Articles were excluded if they studied non-surgical patients, were inaccessible or contained comments or letters.**
Results: **67 articles were included after screening. Three postoperative phases are described. Phase 1 encompasses the post-anesthetic care unit (PACU) stay. Phase 2 covers the time from PACU discharge to hospital discharge, and phase 3 starts after hospital discharge. The review shows that follow-up is provided adequately during the postoperative phases 1 and 2, but phase 3 lacks a proper follow-up. Possible complications for PNBs include pain, nausea and vomiting, dyspnea, neurological damage, and infection should be routinely evaluated postoperatively, preferably the day after discharge. Postoperative follow-up is often provided using a telephone call, but a lost-to-follow-up rate of up to 50% is described. Follow-up rates can be improved using digital follow-up systems, including automatic text messages and applications. Video consultations can be used to evaluate these complications.**
Conclusion: **PNB postoperative follow-up after discharge is not well-provided. Telephone follow-up of PNB has a poor response. Digital follow-up systems, like automatic text messages and applications, can increase follow-up rates. Therefore, we recommend application-based follow-up systems. However, additional studies should evaluate the effect on patient outcomes.**

Keywords: **Locoregional anesthesia, peripheral nerve blocks, ambulatory surgery, follow-up, eHealth.**

Introduction

Ambulatory surgery has continuously grown during the last decades while providing several benefits, including decreased healthcare costs and increased patient satisfaction[1]. In recent years, more complex procedures have been performed on higher ASA-class patients[2]. Joint arthroplasty is a traditional inpatient surgery; however currently also conducted in ambulatory surgery[3,4]. Peripheral nerve blocks (PNB) offer pain relief for several days at home[2,5]. Several advantages compared to general

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anesthesia (GA) and traditional pain therapy made PNBs a standard of pain management for outpatient procedures. PNBs offer lower postoperative nausea and vomiting (PONV) rates, no effect on cognitive function, and allow fast-track protocols. PNB decreases the length of stay (LOS) before discharge[6,7]. Nevertheless, PNBs cause minor-to-severe adverse events. Universal and ambulatory-specific guidelines recommend postoperative follow-up services (POFS) to prevent or timely treat adverse events[8-11]. Because of its similarity to inpatient recovery, recommendations for follow-up in ambulatory PACUs are well documented. Several peer-reviewed discharge criteria have been developed for ambulatory PACU discharge, PACU bypass, and ambulatory surgery discharge[6,12-14]. POFS for phase 3 follow-up should include outcomes including pain, nausea, wound problems, and unplanned admission or readmission. There is insufficient evidence to make recommendations on the form of phase 3 follow-up. Several guidelines advise a next-day telephone call, but the practice differs in each center[8,10,11,15].

Same-day discharge limits bedside follow-up duration and increases the risk of delayed management of adverse events. Poor patient outcomes after adverse events can lead to medicolegal blame[15]. PNBs were responsible for 14% of nonobstetric malpractice claims between 1980 and 2000[16]. PNB complications, and malpractice rates have decreased with modern advances in techniques and technologies[17]. Most malpractice claims consist of adverse events with delayed symptoms, exposing the need for adequate follow-up even after discharge[18]. Ambulatory orthopedic surgery has a high frequency of PNBs and is more frequently associated with PNB-related malpractice claims[19].

This review will illustrate the need for follow-up of PNB and PNB-related complications. A summary of current discharge criteria, fast-track criteria, and follow-up practices for adults undergoing ambulatory PNBs is made. Lastly, this review will evaluate and discuss digital follow-up systems for ambulatory PNBs and their implementation in PNBs in ambulatory surgery.

Methodology

Search strategy

We conducted a literature search using databases including SCOPUS, MEDLINE, and Embase from the earliest record to 01-03-2022.

Search terms

The following search terms were used: "Ambulatory surgery," "Ambulatory surgical procedures," "Anesthesia, Conduction," "Safety," "Follow-up," "Mobile applications," and "Telemedicine."

Selection criteria

The database search included titles, abstracts, and keywords. Search terms were adapted for each database accordingly. All eligible studies were included regardless of design or size. Eligible articles included the evaluation of adverse events of PNBs, follow-up systems for ambulatory surgery and PNBs, and outcomes for ambulatory surgery and PNBs. Comments, letters, inaccessible studies, or articles studying non-surgical patients were excluded.

Ethical approval

Ethical approval was deemed unnecessary after evaluation by the ethical committee of KU Leuven (SCONE). The assigned reference in the SCONE system was MP020673.

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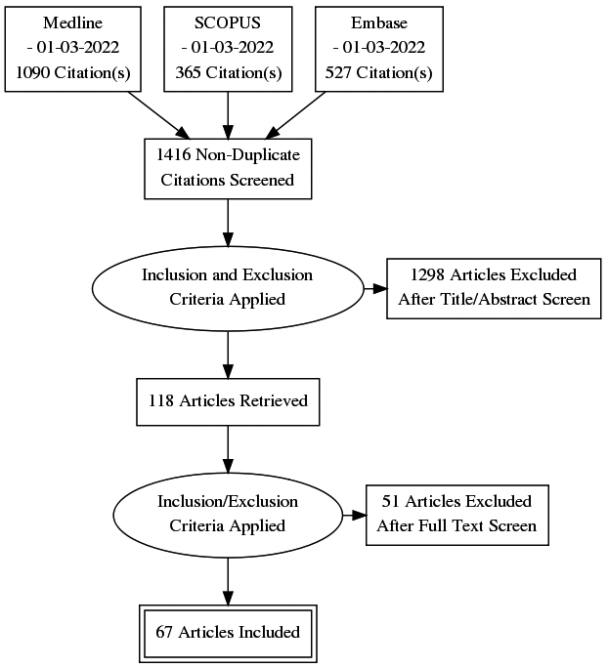

Fig. 1 — Prisma flowchart.

Results

What is follow-up?

Follow-up is the continuous evaluation of patients' recovery carried out immediately after surgery and until the patient has fully recovered. Follow-up practices evaluate the different stages of recovery. Recovery is a return to a normal state of health, mind, and strength and starts at the end of the intraoperative period[20]. Early recovery or phase 1 includes a stay in the post-anesthetic care unit

(PACU), assessing the patient's vital status, and evaluating immediate complications. Intermediate recovery covers the time from PACU exit until the patient is ready for discharge and is called phase 2. The last phase starts after discharge and ends when the patient returns to his preoperative state after full physiological and psychological recovery.

Stadia of follow-up

Phase 1

The anesthetic team should give a perioperative summary to the PACU nurse after transfer from the operating room to the PACU. PACU nurses should address vital signs, nausea, and pain. Adverse events should be evaluated and treated[5,11,21-23].When PNB- or catheter problems occur, an evaluation by the anesthetic team should be performed. A patient's discharge should be done on recovery criteria and not time-based[21,22].

Fast-track

Fast-track practices decrease PACU load and shorten ambulatory LOS by skipping or allowing early discharge of phase 1[24]. PNBs have excellent characteristics for fast-tracking. PNBs have fewer PONV rates and offer additional pain relief. The WAKE score is based on the modified Aldrete score and is used to fast-track patients with PNBs[2,5,25]. Adding zero-tolerance criteria to this score increased the rate of PACU bypass success.5 PACU bypass causes three times more nursing interventions during phase 2[25,26].

Phase 2

Phase 2 prepares patients for discharge with information, instructions, drug prescriptions, and planned appointments. All patients require a driver-escort, and discharge should be postponed if no driver is available[11,23,27]. The postanesthetic discharge scoring system (PADSS) predicts safety and risks of complications or readmission and can assess a patient's readiness for discharge[5,8,11,21,28,29].

Phase 3

The late recovery phase starts after discharge and can take weeks or months before the end is reached. There is no medical supervision, and patients are expected to provide self-care using information and instructions in phase 2[30]. Patients are at risk of readmission should complications occur. Length of surgery (> 1h), intraoperative adverse events, and anesthesia are procedure-related risk factors for readmittance[29,31]. High BMI (>35 kg/m²), age (>65), hypertension, ASA classification (>2), and female sex are comorbidities with higher rates of unplanned admission[29,32].

Evaluation of recovery

Good recovery is an essential outcome after surgery. Several ratings have been proposed to assess recovery. The quality of Recovery scale (QoR-40) is an often-used rating scale. It uses a 40-item questionnaire to evaluate patient support, comfort, emotions, physical independence, and pain[33]. Euro-Quality of Life-5 dimensions (EQ-5D) evaluates five different states (mobility, self-care, usual activities, pain/discomfort, anxiety, and depression) through various questions and visual analog scales (VAS)[34]. The postoperative Quality of Recovery Scale (PQRS) assesses recovery in several domains (physiological, nociceptive, emotive, activities of daily living (ADL), cognition, and patient satisfaction). It assesses long- and short-term recovery using multiple choice questions and numeric rating scales (NRS)[35,36]. PQRS requires a preoperative PQRS baseline[36]. The Post-discharge Surgical Recovery (PSR) scale uses 15 items evaluated using a 10-point scale about five concepts (health status, activity, fatigue, workability, and expectations). PRS measures variations in perceived recovery for patients dismissed within 24hrs after surgery[37]. The Swedish Post-discharge Surgery Recovery (S-PDS) scale is a translated adaptation of PRS. It distinguishes between improved and non-improved patients by comparing scores on postoperative days (POD) 1 and POD 14[38,39].

PNB related complications

PNBs have a lower incidence of PONV and help avoid general anesthesia for patients with a high risk for PONV[7,40-43]. Post-discharge nausea and vomiting (PDNV) occurs more often when GA is used in addition to PNB[40,44-47]. Moderate to severe pain is experienced by up to 78% of patients on POD 1. Pain scores are significantly lower using cPNB[40,41,48,50-53]. Rebound pain occurs in up to 50% of patients and is most intense after bone-related surgery[50,54,55]. Catheter-related complications occur in up to 30% of cases, the most common being leakage[40,52,56]. Catheter failure occurs in up to 8% of patients[40,52,56-59]. Around 4% of patients experienced catheter dislodgement. More than 2% of patients require catheter manipulation or replacement[40]. PNBs could mask pain as an early sign of compartment syndrome and delay diagnosis and treatment[60]. Upper limb nerve blocks can lead to respiratory complications. Diaphragmatic paralysis causes respiratory compromise in patients with pulmonary comorbidities[61-63]. Post-puncture pneumothorax (PPP) occurs in 6 to 20 per 10.000 PNBs and rarely requires intervention[7,40,56,64,65]. With advances in ultrasound-guided techniques, rates of

PPP have decreased.64 Postoperative neurological symptoms (PONS) may happen in up to 8% of PNBs[40]. The risk of long-term nerve injury lasting more than 6 to 9 months is estimated to be about 2.4 to 8 per 10.000 PNBs[17,40]. The risk of infection after single-injection PNB is low[17,47,56,58]. Only 3% of PNB catheters result in infection[17,40,52,56,66]. Lower extremity nerve blocks lead to lower limb weakness and falls in 0.3% of patients[2,15,40]. Continuous PNBs can delay the diagnosis of an injury, mainly if the injury is located in the anesthetized area[67].

Follow-up systems

24-hour phone calls

Telephone follow-up (TFU) is the most common method and can assess several adverse events. TFU decreases patient anxiety and stress while increasing patient satisfaction and confidence after discharge[30-68]. Patients often require multiple calls before they reply[59,69-71]. Patients with catheter PNB benefit from follow-up until after catheter removal. One phone call each night was found to be optimal[57]. High satisfaction rates halve when a patient experiences mild pain. Rates decrease up to 5-fold for severe pain. Catheter complications, block failure, and catheter failure decreased satisfaction by 1.5-, 2.5- and 25-fold, respectively. PONS dropped satisfaction rates by more than 3-fold. PONV decreased excellent satisfaction rates by 40%[40]. There is no evidence that TFU results in better outcomes or reduced unplanned admissions[30]. Available studies have poor design, a limited number of patients, no control group or are conducted only as a feasibility study.

Automated text message follow-up

Text messages are used for a short assessment of postoperative status or forward patients to electronic surveys[69,71,72]. Text message follow-up (TMFU) using automatic text-message systems

Table I. — Common PNB related adverse events.

PHASE 1 AND PHASE 2 ADVERSE EVENTS		
General adverse events		
Adverse event	Min-max rate (%)	Reference
Postoperative nausea and vomiting	0-25	41,47,51,103,104
Pain	0-68	41,51–53,105
Catheter failure	1.8	56
Block failure	0-2.8	40,45,47,50,106
Local anesthetic systemic toxicity	0-0.18	40,47,103,106,107
Upper limb PNB related adverse events		
Adverse event	Min-max rate (%)	Reference
Symptomatic hemidiaphragm paralysis	0-100	40,105,108,109
Transient Horner syndrome	0-29	105,106,109
Hoarseness	8-22	109
Pneumothorax	0-0.015	40,56,105,106
PHASE 3 ADVERSE EVENTS		
General adverse events		
Adverse event	Min-max rate (%)	Reference
Post-discharge nausea and/or vomiting	1-53	40,41,47–49,110
Moderate pain	2-82	40,41,48,50–53
Severe pain	15-78	41,50
Rebound pain	50	50
Catheter failure	2.2-7.9	40,52,56–59
Catheter infection	0-0.3	40,57
Postoperative neurological symptoms	0-41	40,45,47,103, 105,110–112

uses predetermined flowcharts for patient follow-up. Leconte et al. found a 13% loss to follow-up (LTFU) using TMFU, compared with a 43% LTFU using a telephone call[73]. Cittanova et al. saw similar results after ambulatory surgery with text message and telephone LTFU rates of 10% and 50%, respectively. Gessner et al. confirmed increased response rates after ambulatory PNBs and found an average response rate of 91%[72].Based on their preliminary findings, Leconte et al. had nearly 50% alerts for possible complications but decreased alert rates to 32% by improving flowcharts. Gessner et al. managed to identify patients with PONS after PNBs using TMFU. Cittanova et al. attempted to identify potential events using TMFU, but they had difficulties receiving appropriate responses. Cittanova et al. reported an increase in nurse satisfaction and a 33% reduction in costs. Text-message-based questionnaires are slow to complete[74].

Application follow-up

Highland et al. used application follow-up (AFU) to assess pain, pain impact, and PNB effects on day two after discharge. In contrast to studies on inpatient AFU, they found similar response, satisfaction, and convenience rates compared with TFU. These findings, however, are limited by the small sample size[75]. Li et al. found a positive effect on recovery after one day of using AFU for pediatric ambulatory surgery[76]. AFU after ambulatory surgery was estimated by Dahlberg et al. to reduce outpatient healthcare consumption by 39%[77]. After modeling cost-effective scenarios, Armstrong et al. found AFU to be cost-effective[78]. Dotto et al. used an AFU to assess patients' PNB and pain scores and reminded patients to take a scheduled pain drug in a limited feasibility study. Most patients found the app helpful[79]. Assessing symptoms daily for ten days with automatic alerts was found by Simon et al. to prevent one emergency care visit for every 111 patients[80]. Debono et al. tested AFU to evaluate for possible complications for 15 days after ambulatory spine surgery and found it minimizes the need for in-person visits[81]. Pusic et al. noted an anxiety reduction but no effect on emergency care visits, using AFU with enhanced feedback for ten days after ambulatory cancer surgery[82]. Jaensson et al. used the Swedish web-based version of the QoR-40-scale (SwQoR) in an AFU to assess patients' recovery. AFU reduced patients' discomfort due to various symptoms after ambulatory surgery[83].

Video consultation

The recent pandemic has led to a newfound interest in most medical fields in decreasing illness exposure rates. Follow-up using Video Consultation (VFU) is used for several chronic illnesses in internal medicine, including patients with heart failure and endocrine disorders[84,85]. VFU was possible for 72 to 75% of patients after ophthalmologic surgery[86]. After maxillofacial surgery, VFU was possible for up to 96% of patients[87]. VFU achieved a 94.5% satisfaction rate for neurosurgery follow-up[88]. VFU reduced travel time for most patients, and the satisfaction rate was 80% in pediatric plastic surgery care[89]. Postoperative VFU offered equal satisfaction rates to an in-person consultation for plastic surgery, neurosurgery, and orthopedic surgery[90-92]. Patient satisfaction with patient-physician communication was lower using VFU compared to in-person follow-up[90]. After pediatric urologic surgery, VFU reduced median travel times by 18 min[93]. No articles are found evaluating the use of VFU for postoperative follow-up of ambulatory PNBs, Table II.

Discussion

Phase 1 and phase 2 allow for adequate assessment of PNB complications, given that the readmission rate after PNBs is low. Using fast-track protocols can shorten LOS and increase turnover but decrease the length of in-hospital follow-up. There should be a complete evaluation of all patients considered for fast-track. The WAKE criteria have been validated and seem usable to evaluate fast-track eligibility, and zero tolerance criteria can decrease the rate of fast-track failure. Older fast-track criteria fail to incorporate common adverse events and should not be used. Routine evaluation of the recovery process has been used to detect patients with poor recovery, but studies evaluating the use for PNBs are needed. The collected data can also be used as feedback for improving ambulatory centers. The use of a surgery-specific scale (QoR-40, PQRS, PRS) could prove more valuable than general scales, but they lack PNB-related adverse events. PNB-specific scales should include symptoms of PONS.

Severe pain, nausea, and vomiting are one of the leading causes of delayed discharge and unplanned readmissions and should be repeatedly evaluated[44,94]. PNB effectiveness should be assessed for all patients with extreme pain. Catheter PNBs should be assessed for dislodgement or leakage before discharge. Patients need education about possible PNB adverse events before discharge. Patients should only be discharged after approval by the surgical or anesthetic team. Discharge needs to be postponed for all patients with difficult to manage complications.

Currently, no PNB-specific recovery criteria are available. None of the available recovery scores

Table II. — Follow-up systems - part 1.

Telephone follow-up							
Study	Design	Field	Objective	Time	n	Outcomes	Results
Kleinpell (1997) [68]	Non-controlled trial	Ambulatory surgery	Improving TFU comprehension	POD 1 or 2	485	Adverse events Patient satisfaction	0.6% of patients were dissatisfied with the service. Varying rates of side effects were found.
Dewar et al. (2004) [116]	RCT	Ambulatory surgery	Early TFU vs. TFU after five days	POD 1-3 for early TFU, POD 5 for all TFU	222	Pain experience Pain management	Identification and advice of common misconceptions about postoperative pain are possible using telephone follow-up.
Kassman et al. (2012) [117]	Pre-post study	Pediatric ambulatory surgery	Feasibility of TFU for this patient population.	After 1-4 weeks	21	Usability Patient satisfaction Preferences	The success rate after one attempted telephone call was 86%. All parents preferred a telephone follow-up to no follow-up.
Daniels et al. (2016) [30]	Controlled trial	Ambulatory surgery	TFU vs. unreachable patients	POD 1	854	Adverse events Patient satisfaction	Postoperative concerns were lower using telephone follow-up.
Gerceker et al. (2016) [118]	Prospective RCT	Pediatric ambulatory surgery	daily TFU vs. no TFU until an in-person visit	POD 1 until FU	54	Reported adverse events Parents' anxiety	Daily TFU reduced anxiety in parents. Pain was the most reported adverse event. Daily TFU had no emergency visits; no TFU had 23.3% emergency visits.
King et al. (2019) [59]	Retrospective cohort study	Ambulatory upper extremity PNBs	Feasibility and safety of PNB catheter events using TFU	Daily until catheter removal	501	Adverse events Healthcare interventions Response rate	Catheter PNB management using telephone follow-up is safe. The response rate varies between the types of PNB and is between 49 and 65%.
Blanco et al. (2020) [119]	Pre-post study	Pediatric ambulatory neurosurgery	Impact of TFU on patient satisfaction	Within 7 PODs	138	Physician rating	Top box scores for physician rating increased from 85.5% to 95.6% using telephone follow-up.
Automatic text message follow-up							
Study	Design	Field	Objective	Time	n	Outcome	Results
Leconte et al. (2019) [73]	Prospective study	Ambulatory surgery	TMFU vs. earlier assessed data for TFU	POD 1	6343	Response rate Number of alerts Quality of answers	The average response rate using TMFU was 87%. Mandatory telephone calls decreased 4-fold.
Cittanova et al. (2021) [120]	Pre-post study	Ambulatory surgery	TMFU vs. TFU	POD 1	14110	Rate of response Patient satisfaction Nurse satisfaction Cost-effectiveness	The response rate was 50% for TFU and 80% for TMFU. Patient satisfaction was equal. Nurse satisfaction was higher for TMFU. Costs were 33% lower using TFU.
Gessner et al. (2021) [72]	Retrospective cohort study	PNB in ambulatory surgery	TMFU vs. earlier assessed data for TFU	POD 1	89	Response rates Survey of complications Survey of block duration	The average response rate using TMFU was 91%. Further follow-up was required for 38% of patients.
Application follow-up							
Study	Design	Field	Objective	Time	n	Outcome	Results
Marinez et al. (2009) [97]	Pilot study	Ambulatory surgery	Photo-based AFU	Any POD	96	Feasibility of photos for wound complications	AFU using photos was able to assess 96.7% of local complications
Debono et al. (2016) [81]	Pilot study	Ambulatory lumbar discectomy	AFU vs. in-person FU	POD 1-15	60	Response rate Usability Patient satisfaction	The response rate was 60% App worked as intended. The satisfaction was excellent.

Table II. — Follow-up systems - part 2.

Dahlberg et al. (2017) [77]	RCT	Ambulatory surgery	Standard vs. AFU	POD 1-14	719	Cost-effectiveness Gained quality-adjusted life-years Quality of postoperative recovery	AFU was more cost-effective. There was no difference in the quality of recovery.
Jaensson et al. (2017) [83]	RCT	Ambulatory surgery	AFU vs. paper-based follow-up.	POD 1-14	997	Quality of postoperative recovery	AFU decreased discomfort originating from several postoperative symptoms.
Armstrong et al. (2017) [121]	RCT	Ambulatory breast surgery	AFU vs. in-person follow-up	POD 1-30	65	Number of in-person visits until POD 30 Number of telephone calls and emails Patient convenience Patient satisfaction Adverse events	AFU reduced in-person care by 2.5x AFU patients sent 4.3x as many emails. AFU had higher convenience scores. No other differences were found.
Dahlberg et al. (2017) [122]	Secondary analysis	Ambulatory surgery	Patient initiated AFU	POD 1-14	494	Number and reason of contacts. Quality of postoperative recovery	Contact was initiated by 17% of the patients Patients who initiated contact had poorer recovery.
Lopez et al. (2019) [123]	Pilot study	Ambulatory surgery	AFU vs. TFU	POD 1-20	20	System usability Patient satisfaction Quality of life	Quality of life was higher in AFU. The AFU system was usable and satisfactory.
Tan et al. (2019) [95]	Prospective cohort study	Ambulatory surgery	AFU vs. TFU	POD 1	12503	Response rate Completeness of data collection	Response rates were increased from 66% to 77.5% using AFU instead of TFU. The data collection rate was nearly doubled to 100% using AFU.
Dotto et al. (2019) [79]	Pilot study	Single-shot PNB	AFU	POD 2-7	29	Usability for PNB and pain assessment, pain medication scheduling	The participation rate was 69%. AFU was able to assess PNB & pain and schedule pain medication.
Highland et al. (2019) [75]	Pilot RCT	Ambulatory surgery in a military hospital	TFU vs. AFU	POD 2	50	Response rate Patient satisfaction Nurse satisfaction Pain scores PNB assessment	TFU and AFU had similar responses, satisfaction, and convenience rates. AFU increased pain and pain interference. AFU increased nurse satisfaction
Li et al (2019) [76]	Prospective study	Pediatric ambulatory indirect inguinal hernia repair	TFU vs. AFU	POD 1	127	Response rate Postoperative recovery Parent satisfaction Time for follow-up	AFU and TFU had similar response rates. AFU non-significantly improved the quality of recovery. AFU reduced follow-up timing.
Ooi et al. (2020) [69]	RCT	PNBs	TFU vs. AFU	POD 14-21 and POD 90-100	120	Response rate	The response rate was 15% for TFU and 27% for AFU at POD 14-21. The response rate at POD 90-100 decreased to 8% for TFU and 5% for AFU.
Pusic et al. (2021) [82]	RCT	Oncologic ambulatory surgery.	TFU: monitoring vs. enhanced feedback	POD 1-10	2624	POD 1-30 emergency care visits Patient anxiety Nursing utilization	There was no difference in emergency care visits. Enhanced feedback decreased anxiety and nursing workload.
Simon et al. (2021) [80]	Retrospective cohort study	Ambulatory surgery	Implementation of AFS	POD 1-10	7165	Emergency care visits within POD 30 Nurse workload	AFS decreased potentially avoidable emergency care visits by 22%. Nurse call workload increased by 34%.

Table II. — Follow-up systems - part 3.

Video consultation							
Study	Design	Field	Objective	Time	n	Outcome	Results
Rollert et al. (1999) [98]	Retrospective study	Maxillofacial surgery	Feasibility of preoperative video assessment	/	43	Correct assessment	100% of patients were assessed correctly
Canon et al. (2014) [93]	Retrospective pilot study	Pediatric urological surgery	VFU vs. TFU	Within POD 90	61	Travel distance	Travel time and distance were reduced using VFU.
Westra et al. (2015) [90]	RCT	Plastic surgery	VFU vs. in-person follow-up	Six weeks postoperative	31	Satisfaction Convenience Communication	VFU had similar rates of satisfaction Communication was negatively impacted
De Biase et al. (2020) [92]	Retrospective study	Neurosurgery	Effect of COVID-19 on in-person visits	/	1258	Rate of in-person and remote patient contacts	In-person visits and telemedicine, including VFU, had similar satisfaction rates. COVID-19 increased the rate of remote patient contact.
Kim et al. (2022) [89]	Prospective study	Pediatric plastic surgery	Satisfaction with video contact	/	78	Satisfaction rate	23 postoperative VFU were performed. The satisfaction rate was high.

Abbreviations: FU: Follow-up; TFU: Telephone follow-up; TMFU: automated text message follow-up; AFU: Application follow-up; VFU: Video follow-up; PNB: Peripheral nerve block; POD: Postoperative day; RCT: Randomized controlled trial.

offer PNB-specific recovery items. Standardized protocols for POFS allow for more consistent and structured information retrieval[68]. Common complications should be evaluated in all patients who received PNBs. Addressing these issues could improve patients' experience and satisfaction and decrease readmission rates. We believe it might be possible to develop a risk score for readmittance and extend the follow-up period depending on the patient's risk. Further research is required to investigate the development and validation of such a score.

Requirements for POFS differ in each country. The Australian Council on Healthcare Standards (ACHS) requires a phone contact within seven days of discharge[95]. IAAS and ASA guidelines recommend a next-day TFU[8,11]. ASA guidelines consider it best practice to have a helpline available until 24h after discharge[8]. TFU has several shortcomings and does not influence outcomes or unplanned admissions. It requires patients' availability to answer and has very high LTFU rates. Currently, there is only limited data on the influence of TFU on PNBs.

TMFU does not require a smartphone as nearly all mobile phones have SMS capabilities and increase the participation of elderly patients. However, TMFU has shortcomings: the follow-up questions are limited to yes/no, multiple-choice, or numbers. It requires a correct input, and if an inappropriate answer is made, the system might not be able to process the response. Repeat evaluation of patients' recovery rates might be possible, but the questionnaires are slow to fill in using text messages. Current studies on TMFU have been limited to one automated follow-up contact the day after surgery. Further research could include an extended follow-up period.

Current research on ambulatory AFU is limited. There is a lack of evidence for the contents, usage, effects, and validation of an AFU for PNBs. Most of the studies have studied the usability of AFU. Only one study was focused on PNB assessment using AFU. Only a limited number of studies could evaluate and compare outcomes. Using AFU to evaluate PNBs after discharge could improve patients' response rates and satisfaction and decrease healthcare costs, but more PNB-specific studies are needed.

The widespread use of computers and mobile phones has led to the development of digital telemedicine. When adequate encryption is provided, digital services can become more private and secure than telephone services[96]. Compared to telephones, digital services allow for advanced services and visual media sharing and enable patients to read and reply at any time. A pilot study by Martinez et al. successfully used digital photos to evaluate surgical wounds[97]. There are several advantages to TMFU and AFU compared to TFU. They both increase the rate of successful follow-up. TMFU and AFU can determine which patients require in-depth follow-up to assess for adverse events. Using flow-chart-based questionnaires, an alert can be triggered when an adverse event is suspected, and further evaluation

can be made. Developing and implementing an alert system can be complex and requires continuous adaptations and a careful balance in sensitivity between false alerts and undetected complications. Current studies suggest that an automated system's in-depth assessment of adverse events is impossible. However, these trials used an elementary detection algorithm. Improving the algorithm could increase sensitivity for adverse events and even automatic differentiation. There are limitations to what an automated system can offer. No automated system has been developed to replace TFU fully, but automated FU systems can decrease the number of telephone follow-ups needed by 62 to 71%[72,73,95]. Clinician-patient follow-up should be conducted by telephone or in-person. Daily follow-up can be easily provided using an automated system to extend the follow-up service. Repeat assessments can provide enhanced feedback to patients, evaluate their recovery, and provide information about symptom severity.

Telemedicine using VFU has been studied as soon as the development of the Internet allowed for a fast and reliable video connection. VFU has been used as early as 1999 for the preoperative evaluation of patients for maxillofacial surgery[98]. Since its introduction, VFU has been used to replace inpatient consultations for diseases and surgical evaluation. VFU achieves similar satisfaction rates, but other effects have limited evidence or have not been studied. For chronic illnesses, contradictory effects on outcomes have been found. In large areas where patients may be hours from the nearest medical center, VFUs can reach even the most remote patients with internet access. VFU can be used for postoperative follow-up consultations, but a structured method of consultation should be used to improve communication. There is currently no knowledge of VFU for next-day follow-up in ambulatory centers. We believe it has similar limitations as TFU and might even lead to higher LTFU rates. As with TFU, patients might be unable or unwilling to respond when the call is initiated, requiring multiple follow-up attempts. VFU might be invasive to a patient's privacy and challenging to schedule all next-day follow-up appointments. However, VFU can play a role in ambulatory surgery as a replacement for in-person visits to evaluate adverse events. The evaluation and follow-up of catheter-related infections are possible, and VFU can visually assess some causes of PNB catheter malfunction.

Using the currently available knowledge, we suggest the implementation of AFU over TMFU. For inpatient surgery, AFUs after discharge achieved higher response rates, prevented phone calls and emergency room visits, and were helpful and reassuring to patients[99-102]. AFU can be offered by a phone application or a web-based system. Web-based systems do not require installation and might offer higher participation rates. In comparison to text messages, applications provide many additional benefits. The information and instructions provided during phase 2 can be shared digitally using flyers, photos, and videos. Procedure-specific information packages can tailor the information to the patient's needs, and additional plug-ins can prevent common complications. For example, using the start of the PNB, the estimated timing of when the effect has passed can be made, and the application can give a notification to take scheduled painkillers. Using VAS or NRS pain scores, reminders to take pain medication can be made. The recommendation can be adapted to the patient and operation-specific pain therapy. Strict registration and verification of medication usage should be made if using AFU for medication reminders to prevent overdosing. VFU can be used to replace an in-person visit to assess adverse events. VFU should be used for all patients who are COVID-19 positive but require further evaluation.

Conclusion

Phases 1 and 2 offer adequate follow-up for PNBs and can successfully deal with adverse events. TFU is the most used follow-up system after discharge, but it has poor response rates, and up to 50% of patients are lost-to-follow-up. Digital follow-up systems, including text messaging and applications, can increase response and follow-up rates. Digital follow-up systems should be used as a preliminary evaluation. The system can differentiate between patients with an uncomplicated postoperative course and patients with possible adverse events. Using this differentiation, the rate of patients requiring actual contact can be decreased by half and even more if more sensitive flow charts are developed. VFU can be used to evaluate PNB-related adverse events without an in-person visit. With the current knowledge, AFU seems to offer the most advantages. Still, evidence of different follow-up systems for PNBs is limited. Additional research is needed to further develop and validate these digital systems.

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