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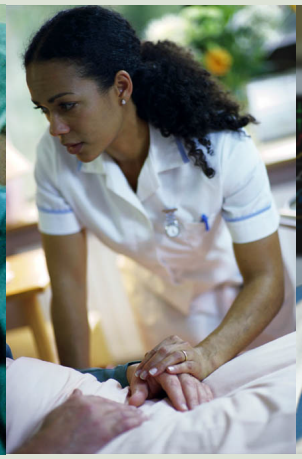

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Contents

Peri-operative nurse surgeons' assistants in day surgery an emerging role within Australia's health system

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Abstract

As Australia has only recently adopted the Nurse Practitioner role within its public health system, the training of nurse practitioners in day surgery is limited. With a focus on Peri-operative Nurse Surgeon's Assistant (PNSA) Nurse Practitioners, and from a trainee perspective, this paper seeks to identify the overall benefits of the role, specifically to day surgery. Required training and recognition, the future of training PNSA Nurse Practitioners in Australia and some brief historical facts about Nurse Practitioners and PNSAs within Australia are all discussed. There is no doubt that the day surgery environment is an ideal area for both nurse practitioner training and employment

Keywords: Nurse practitioner; Nurse practitioner training; Registered nurse first assistant; Peri-operative nurse surgeon's assistant

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Nurse Practitioners in Australia – History & Statistics

The work towards the recognition and training of nurse practitioners in Australia began in 1990. However, it wasn't until November 1998 that the Nursing Act was amended to incorporate nurse practitioners. In Dec 1999, the first trial of nurse practitioners started in the Australian Capital Territory in the areas of wound care, sexual health, mental health and the military. A year later in Dec 2000, the first nurse practitioners were authorized, and the Australian Association for Nurse Practitioners was formed in 2003. Currently in Australia, state registration exists for nursing . Each state has gradually begun to authorize or endorse nurse practitioners with the latest, the Northern Territory, only legislating in September 2008. There are now approximately 370 nurse practitioners endorsed or authorized around Australia, encompassing many different nursing specialties. Each state now boasts a Chapter of the Australian College of Nurse Practitioners. This college was newly registered in 2009 and was the product of many years of hard work by the Association of Nurse Practitioners [1].

Peri-operative Nurse Surgeon's Assistant (PNSA) – Brief History

Jane Rothrock (1997) is the main author of the peri-operative nurse's bible, "The Alexanders (Care of the Patient in Surgery)". She is also one of the pioneers of the Registered Nurse First Assistant (RNFA) or equivalent Australian PNSA role in the USA. In Rothrock's text for RNFA's [2], she states: "Quality surgical care encompasses more than the safe performance of a surgical intervention with the achievement of its physiological intent. Patient preparation for the surgical intervention itself and for the ability to participate in rehabilitation and self-care at home, are important responsibilities of the Registered Nurse First Assistant". This is a succinct definition of the importance of the PNSA role in providing holistic care to the surgical patient.

Attention should be paid to a few important words within this statement by Rothrock. They are 'quality surgical care'. This is a very topical choice of words, which asks one to analyse the surgical practice as a whole. The gold standard for patient care is the holistic care paradigm. The questions one needs to ask are: Do I provide truly holistic care to my patients? If so, at what cost?

In day surgery, the patient is not always under the care of a doctor or nurse 24 hours a day, 7 days per week, and this often increases the need for patients to be in phone contact with someone for advice. This can be one of the many hefty social burdens placed on the surgeon. Could this burden could be shared with a clinical assistant who knew the patient as well as the surgeon, who understands the surgeon's preferences, and with many years of experience and training under the surgeon's guidance, and one who could see the patient if required and vet all of those worried patients who just simply require a little bit of reassurance? Is this person the nurse surgical assistant?

This is just one of the many benefits of working with a PNSA, especially a PNSA nurse practitioner.

This paper endeavours to identify a different way to holistically treat surgical patients, and a way which hopefully will reduce the cost, if not physically, at least mentally and socially. Through personal experience as a PNSA nurse practitioner trainee, this has proven most beneficial in the day surgery environment.

PNSA – Role Defined

To provide true holistic care, the PNSA requires knowledge. This is attained through peri-operative nursing experience and 5 years is the mandatory pre-requisite for acceptance to the PNSA postgraduate course in Australia.

The assessment and transference of clinical information and knowledge is expertly and professionally performed by the PNSA through the pre-operative assessment. This pre-operative assessment is thorough, and conducted with 8 essential items. These are:

1. The Patient History

Quite often the patients appear to give a different history content to the PNSA during the pre-operative consultation than the one that they gave during the surgical consultation. Being more social, but no less

important, this consultation is an opportunity to learn more about the patient's home situation. This is especially important in same day discharge, where the vast majority of the post-operative care will be in the home. This can then shed light onto factors that eliminate the patient's suitability for day surgery or more often highlight risks that need to be addressed prior to admission.

2. The physical examination

Patient suitability for a booked procedure, especially within a day surgery facility, comes down many a time to the surgeon's physical examination technique and psychosocial status assessment. By using a PNSA to perform this also, combined with the history, a more accurate discharge plan can be formulated and for those with long elective booking times, patients that may have appeared suitable at consultation time may have the ability to be re-evaluated prior to surgery.

3. Assessment of psychosocial status

4. Assessment of the potential complications

Using all of the identified forms of assessment, the PNSA can formulate an assessment of potential complications – procedure specific. Patients can be risk rated for the known post-operative complications based on their pre- operative assessments. Any patients that fall into the high risk categories can be noted for re-assessment or post-operative planning and all other risks can be identified to the hospital staff and monitored by either the surgeon or PNSA throughout the patients peri-operative experience (Carroll, 2007 [3]).

5. The Nursing Diagnosis

The main aim of the nursing diagnosis is to bring together all of the prioritised information and risk assessments for evaluation by the surgeon, management by the hospital and nursing staff, and recommendations for further investigation or intervention.

6. Collaboration and Communication with Surgeon

It is important therefore that a good relationship exists between the surgeon and their PNSA. As with any team environment, good communication is paramount to a successful team outcome.

7. Problems & Problem Solving Strategy

In an interesting Canadian study from 2008, it was identified that patients with communication issues were 3 times more likely to experience a preventable adverse event in an acute care setting (Bartlet et al, 2008 [4]). This re-iterates the importance of thorough pre-operative assessment, risk management and the initiation of risk prevention strategies prior to admission.

8. Education

It is imperative that as part of the pre-operative assessment, the PNSA takes the opportunity to answer any patient questions, and prepares the patient for the operative experience through education. This is procedure specific and should include information about the pre-operative, intra-operative and post-operative treatment.

There are many benefits to conducting this education and Fox (1998) [5] identified the following:

a. Relieving anxiety

b. Increasing self esteem by increasing self – efficacy

c. Speedy recovery

d. Reducing hospitalization costs

e. Decreasing the amount of perceived immediate and residual pain.

The PNSA, having a thorough understanding of the surgical procedure and the surgeon's preferences with that procedure, and having worked closely with the surgeon in the operating theatre, will be in a unique position, with greater time and at less cost, to educate the patients on best practice for an optimal surgical outcome. This is a tried and tested scenario and a major part of the PNSA role.

Intra-operative Role

Each PNSA performs the normal duties of a surgical assistant, within their scope of nursing practice and as required by the surgeon with whom they are working. It is also important to note here that the added Nurse Practitioner qualification can allow the PNSA to perform more duties under a wider scope of practice.

The patient's response to the PNSA's presence in theatre has been noted to be very positive. They say they feel more comfortable knowing that there is someone that they feel they know in the theatre 'looking after them'. This may seem like just a bit of PR, but for the nervous patient this reassurance and emotional support is invaluable.

Post-operative Role and On Call Duties

With all surgical procedures, effective post-operative wound management is essential. 'Successful nursing care of surgical wounds is dependent on the nurse's knowledge and understanding of normal wound healing physiology, the type of surgery performed, the method of closure and the optimal treatment of the resultant wound. Using this knowledge, nurses can provide a systematic and holistic patient assessment, and consider any potential wound-related complications.' (Vuolo, 2006, [6]). A PNSA, who has undertaken advanced training in these areas and knows the specific surgeon's preferences can instigate and manage a wound management protocol for those patients within the high risk categories.

This also leads to the 'on call' protocol. Trying to attain a work life balance in this technologically savvy world, where one is always expected to be available 24/7, is extremely difficult and sometimes, depending on the specialty concerned, impossible. Having the ability to have a buffer, be that even part time, is of huge benefit.

Being trained in the surgeon's preferences and working under their guidance, the PNSA can provide an interface 'on call' service to the patients. This provides benefit to the patient (to relieve anxiety) and to the surgeon, to relieve the burden of the 'always working, always on call' scenario that we are now facing. Through experience it has been found that the patients have not only felt more secure and have been more compliant in their post-operative care with the 'on call' service available, but it has also served as good PR, relief of patient anxiety, and perceived as added value to the procedure that they are paying for.

The benefits of a PNSA to the Surgical Practice

Today's surgical patient is more knowledgeable than the surgical patient of twenty years ago. Due in part to globalisation and the ability to obtain information with greater ease over the internet, the modern surgeon needs to provide a superior service for less money and under greater scrutiny than ever before.

So how can a better service be provided? The answer is optimal holistic care. The patient has a decreased risk of sub-optimal surgical outcome when this care is performed.

This is simply the benefit of the PNSA to the surgical practice today. Being superiorly trained through their peri-operative experience, and by understanding the surgeon's individual preferences and practices they can provide an effective interface. They can, through sensitive and careful communication, provide a supportive, empathic, yet professional, face for the surgical practice (Norvedt, 1996 [7]) thereby reducing the litigious intent of the patient and the demands on the surgeon's precious and costly time.

This combination of PR and knowledge is expertly and professionally performed by the PNSA.

The benefits of a PNSA to the Day Hospital

Before we identify the benefits I would like to mention a few of the challenges faced by day hospitals at the present time.

These have been identified by the Queensland Health jurisdiction as, 'pressure from a growing and ageing population, increasing chronic disease in the community, rapid development of health technologies, potential workforce shortages and increasing costs, which are not necessarily matched by increases in the health funding base.' For private facilities and day hospitals especially, the most prominent of these is finance and staff.

To assist with these issues, especially those of finance and staff, the PNSA can help to increase efficiency and decrease costs. This is achieved very simply. They are another set of hands, someone to help the surgeon with their notes, someone to advise the scrub scouts of the surgeon's preferences, someone to go out with the patient and give a nursing handover, and the list goes on and on. It is important to remember that the PNSA Nurse Practitioner was once an experienced peri-operative nurse. This person can, with the consent of the surgeon, assist with teaching of inexperienced staff and most importantly can be an interface and source of knowledge for the nursing staff.

Most importantly, the PNSA Nurse Practitioner does not need to be paid out of the nursing budget and most PNSA's in Australia work in collaboration with a single surgeon, and are remunerated by them.

Recently in Australia, the Federal Government has announced that Nurse Practitioners will be allowed access to the Medicare Benefits Scheme (MBS) and the Public Benefits Scheme (PBS) systems, therefore hopefully being remunerated for their work by Government subsidy. Unfortunately, it has not yet been clarified as to how this will happen. However, it is gratifying to see that the Australian Government has finally recognized the benefits that a Nurse Practitioner can provide to the provision of health care services and has opened the door to the possibility of access to the MBS surgical assisting item numbers by PNSA Nurse Practitioners.

The benefits of a PNSA to the patient

Some of the benefits of the PNSA to the patient have already been identified. It is pertinent to look at what Queensland Health feel are the challenges facing health care consumers today.

> 'Health care consumers also face challenges, such as managing and understanding the growing body of information about health, disease and treatment options; managing complex self-care and self-medication regimes; interfacing with multiple care teams across treatment for chronic and co-morbid disease, and issues of timely and coordinated access to health service.'
>
> 'New directions in health service emphasize multidisciplinary, collaborative team approaches to care, in acknowledgement of the fact that no single health care provider or service model can adequately meet the complex requirements of the 21st century health care consumer. The nurse practitioner is a model of workforce reform that adds a new type of clinical service to the multidisciplinary team. ' [8].

This clearly outlines the need for the PNSA role.

PNSA Training in Day Surgery – Why it is superior to Inpatient Hospital Training

The answer to this is simple. In an environment where the patients total perioperative care is conducted within a day, the PNSA can easily be involved in the whole experience. This makes training more streamlined and less limited to separation of all of the aspects of the perioperative experience. This is even more emphasized in freestanding day surgery facilities as the team is often smaller and the physical surrounds more conducive to holistic perioperative training.

PNSA Nurse Practitioner Training – The Future.

Currently in Australia there is a dilemma. The training of nurse practitioners and PNSA's has been separated and this is one of the reasons that the role has not been widely embraced. PNSA's can be more adequately qualified by combining the training of the PNSA and the nurse practitioner to attain recognition.

Unfortunately, despite many PNSA's working within Australia, there is no national body for this nursing specialty. A voice for this specialty is urgently required.

The key to the success of this nursing specialty and nurse practitioner sub specialty is in the access to the Medicare Benefits Scheme which, due to the Government's recent announcements, may now become available to Nurse Practitioners. So that this role may more widely be embraced and respected by the surgical community, all the currently qualified PNSA's, many no longer working as assistants, may need to complete the Masters of Nurse Practitioner Studies.

The last important aspect of the future is that of recognition of PNSA status. It should be suggested that this training be re-thought as much of it is on the job training and very specific to the surgical specialty in which the PNSA is working. Should a medical model of postgraduate training be considered?

Overall, this paper has outlined the advantages of an emerging nurse practitioner role within Australia, that of the PNSA Nurse Practitioner. That role is of one provision of continuous holistic nursing care to the surgical patient whilst providing assistance to the surgeon, nursing staff and hospitals in which they work. The training and employment of these PNSA Nurse Practitioners in an ambulatory surgery setting is considered a high priority in the delivery of quality health care to the Australian community.

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Non-attendance rates at a regional plastic surgery day case theatre and the associated cost implications to the unit

K. Kok[a], S. Singh[b]

Abstract

Aim: This study aimed to measure our plastic day surgery non-attendance rate and its cost implication.

Methods: A study was carried out from January to June 2007. Non-attenders to plastic day surgery were identified. The financial cost was calculated.

Results: There were 895 day surgery patients with 16 non-attenders (1.79%). The cost to the hospital trust was a total of £18,350.

Conclusion: Non-attendance for day surgery wastes hospital resources and has significant financial implications. A low non-attendance rate maximises theatre utilisation and earnings. We also describe our practice to show how our low nonattendance rate was achieved.

This study was presented at the British Association of Day Surgery Scientific Meeting, June, 2008.

Keywords: Ambulatory surgery; Non-attendance; Efficiency; Day case; Cost effectiveness

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Introduction

Patients who fail to attend their day surgery appointments incur an opportunity cost in terms of the surgeon's time as well as an economic cost to the trust. This economic cost usually consists of a fixed cost for consumables, theatre space, time and staff; as well as a lost opportunity cost (ie. lost income for not performing operations on non-attenders). This latter value is variable depending on the specialty and operation to be performed. In order to measure the financial impact of plastic day surgery non-attenders to the trust, a study was undertaken to determine the number of non-attenders over a 6 month period. Data gathered from patient's notes such as reasons for non-attendance and 3 patient demographics are discussed. The fixed and lost opportunity costs are calculated on an individual patient basis to determine the economic impact. Our current practice in maintaining a low non-attendance rate is then described.

Methods

A retrospective study over a period of 6 months from January to June 2007 inclusive was carried out at the plastic surgery department at Selly Oak hospital. Day case plastic surgery is undertaken in two theatres by 10 consultants and the ward attendance books for these theatres were examined. The non-attenders for day case plastic surgery over the 6 months were identified and their medical notes were examined, noting down their sex, age, history of previous non-attendance, individual operations and the reasons for not attending. The financial cost to the hospital trust was calculated by adding the fixed costs (cost of theatre facilities, staff and consumbles) and the lost opportunity cost (lost income for not performing operations on non-attenders). The figures for the fixed costs and the individual operations were obtained from the trust's finance department.

Results

A total of 895 plastic surgery patients were booked for day surgery over the period of 6 months. There were a total of 16 non-attenders giving a non-attendance rate of 1.79%. Of the 16 patients, 12 were male and the age range was from 17–77 years with a median of 43 and a mean of 39 years. 3 patients had a history of at least 1 previous nonattendance at either a clinic or other local anaesthetic list. There were various reasons for non-attendance listed in the ward books. Where the reason for non-attendance was not stated, patients were telephoned and reasons were obtained (see Table 1). Following their non-attendance, 8 of the 16 patients re-booked for surgery.

Table 1 Reasons for non-attendance given by patients.

Reason for DNA	Number
Changed mind	2
Did not receive letter	2
Forgot appointment	4
Afraid of surgery	1
No time	2
Unwell	3
Miscommunication	2
Total	**16**

In order to determine the financial cost to the trust of these non-attenders, the fixed costs and lost opportunity costs were added together. To obtain the fixed costs and costing of various procedures, the trust's finance department was contacted.

In terms of the fixed costs, 1 day case session cost the plastic surgery department £430.

This included the expenditure required to run the theatre session (medical staff, nursing staff, theatre facilities, ward facilities, electricity, etc). Making the conservative assumption that each session could accommodate 4 cases on average, the total cost for 16 non-attenders would be 4 sessions or £1720 (£430 x 4).

There was also a further charge known as the 'non-pay charge' for drugs, dressings, sutures, instruments and other miscellaneous items. This was incurred by the trust on the plastic surgery department for each individual patient regardless of whether the patient attended or not. This charge was variable and was dependent on the complexity of the operation with minor cases costing £110, intermediate cases costing £230 and major cases attracting a cost of £540. By definition, only minor cases could be performed in day surgery. Therefore all 16 cases of non-attendance attracted a 'non-pay charge' of £1760 (£110 x 16). The total fixed cost was therefore £3480 (£1720 + £1760).

In terms of the lost opportunity costs, each individual operation attracted a different payment from the Primary Care Trust (PCT). The operations that were scheduled for each patient but not performed, along with their charge to the PCT is listed (see Table 2). The total lost opportunity cost in our study period amounted to £14870, giving a total cost to the trust of £18350 (£14870 + £3480)

Table 2 Procedures with associated cost.

Patient	Procedure	Cost (£)
1	Nipple reconstruction	772
2	Carpal tunnel decompression	724
3	Excision biopsy of 3 lesions	571 x 3 = 1,713
4	Excision BCC and direct closure	2,785
5	Excision benign cyst	571
6	Repair split ear lobe	1,060
7	Excision nail spike middle finger	689
8	Excision biopsy lymph node	2,441
9	Excision myxoid cyst ring finger	571
10	Excision nail spike index finger	689
11	Excision rhinophyma	571
12	Excision cyst temple	571
13	Excision benign naevus	571
14	Excision benign naevus	571
15	Excision congenital melanocytic naevus	571
16	Excision benign naevus	571
	Total	**14,870**

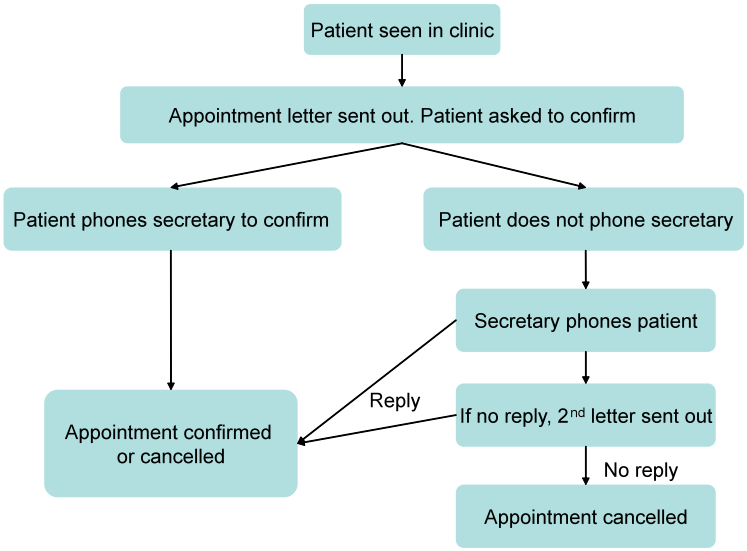
Discussion

There has not been any previously published figures on the non-attendance rate in a plastic day surgery unit however non-attendance in other fields and specialties is well documented along with the methods employed to reduce this. Lee and McCormick found that by using telephone reminders, their non-attendance rate in outpatient gastrointestinal endoscopy fell from 23.3% to 5.7% over a 2 month period [1]. Similarly, Dockery et al. found that their non-attendance rate of care of the elderly clinics fell from 21% to 5% by using telephone reminders [2]. This measure was also effective in reducing non-attendance in adolescent clinics [3].

Another novel method of reminding patients about their appointments include using 'short message service' or SMS via mobile telephone. Geraghty et al found a reduction in their ENT outpatients non-attendance rate from 33.6% to 22% by using SMS [4]. The cost of using a SMS service to remind patients has been shown to equate to £7.50 per non-attendance avoided [5]. This cost may not be acceptable in improving attendance rates at outpatient clinics however it is a relatively cheap method of reminding day surgery patients considering that the 16 non-attenders in our study cost our trust an average of £1,147 per patient.

The non-attendance rate at our plastic day surgery unit is a relatively low 1.79% compared to other specialties. This low rate may be related to the surgery carried out whereby the majority of cases involve either skin cancer excisions or may be secondarily aesthetic in nature (ie. involve the excision of skin/subcutaneous lesions in prominent areas). Nevertheless, we have included a flow chart of our current practice to show how our low non-attendance rate was achieved (see Figure 1).

Figure 1 Flowchart showing process of appointment confirmation



Conclusion

Patient non-attendance at clinics and theatre sessions is a difficult problem. It results in under utilization of resources and clinical personnel who are scheduled to attend to the patient who is absent. It wastes hospital resources, lengthens waiting lists and has significant financial implications to the Trust and surgical department as illustrated in this audit. With the recent introduction of the 18 week referral to treatment (RTT) objective [6] by the government coupled with the economic difficulties that the NHS is facing, it is important that we maintain a low non-attendance rate to maximise theatre utilization, increase staff efficiency and earnings via payment by results.

All figures correct for financial year 2007/08

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Efficacy of a direct booking system: a prospective cohort study

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Abstract

Patients with recurrent tonsillitis are traditionally seen in the outpatient department and their suitability assessed prior to booking for tonsillectomy. The waiting time to the outpatient appointment in our unit is up to 18 months. Our aim was to reduce this lengthy waiting time by offering the direct booking system and to assess its efficacy and acceptability to patients.

Methods: This was a single-blinded cohort study consisting of 3 parts:

Part 1: Patient selection

Patients (adults, children > 20kg) referred by GP for tonsillectomies were sent a questionnaire (Q1) to assess their suitability for tonsillectomy.

Part 2: The returned questionnaires were reviewed by the consultant and patients that fulfilled the criteria for tonsillectomy were booked for the procedure.

Part 3: On the day of admission, the patients were assessed by a registrar (senior resident) using another questionnaire (Q2). The registrar was blinded as to whether the patient was booked for surgery via the traditional outpatient review or via the questionnaire and information leaflet.

Results: There were 22 patients booked for tonsillectomy via the traditional outpatient system and 20 booked via the direct booking system. Patients booked through the outpatients had to wait approximately 12.8 months while the direct booking patients only waited 5.3 months before surgery. Questionnaire assessment of the patients and parents knowledge of the procedure (Q2) showed both groups to be equally lacking in knowledge regarding the risks and complications of the procedure.

Conclusion: The direct booking system for tonsillectomy provides an efficient way for selecting patients requiring this procedure. It is acceptable to patients and significantly reduces the waiting time and the load on outpatient appointments.

Keywords: Direct booking system; Tonsillectomy

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Introduction

Tonsillectomy is one of the most common otolaryngology procedures. Patients requiring this routine operation often have lengthy waiting times for outpatient appointments and surgery.

Traditionally, referrals for tonsillectomy are made by general practitioners (GPs). GPs refer patients to the otolaryngology clinic by letter, which, as well as containing information regarding their complaint, also contains supplemental clinical information about the patient (i.e. age, sex, social status, medical conditions, and medications). These referrals are not standardised. The referrals are reviewed by a consultant otolaryngologist and a time schedule for the outpatient clinical assessment is proposed on the basis of the information in the referral and the availability of appointments. The waiting time between GP referral and outpatient appointment in Beaumont Hospital, Dublin can be as long as 18 months. Having been reviewed by an otolaryngologist in the clinic setting, if patients are deemed to require surgery, and are suitable surgical candidates, they are given information about the procedure and counseled regarding the options, risks and complications of the surgery. Patients who wish to proceed with surgery, are placed on the hospital waiting list. The waiting time for tonsillectomy once patients have been listed in Beaumont Hospital is up to 12 months.

Traditionally it would be considered unsafe to book patients for routine tonsillectomy without an outpatient assessment by a trained otolaryngologist. However the decision as to whether tonsillectomy is indicated, is made on the basis of the patient's history and therefore we propose that patients referred by their GP may be safely selected for surgery, on the basis of a detailed questionnaire which is filled in by each patient and once selected these patients may be given adequate written information by mail. Thus the need for prior assessment in the outpatient department can be obviated. We term this the direct booking system.

We propose that this 'direct booking system', may reduce the lengthy waiting time from initial GP assessment to surgery and also the overall cost involved.

The 'direct booking system' for tonsillectomy is based on the concept that the decision made to proceed with tonsillectomy is based on the history and not the clinical appearance of the tonsils (Scottish Intercollegiate Guidelines Network – SIGN) [1]. It is a questionnaire based system, designed to bypass the traditional outpatient assessment.

The aim of this study was to assess the efficacy of a 'direct booking system' in selecting patients for tonsillectomy, in reducing waiting time from referral to surgery and in increasing the cost-effectiveness of this process.

Methods

This study was a single-blinded prospective cohort study that consisted of 3 parts:

Part 1: Patient selection

Patients (adults, children > 20kg) referred by GP for tonsillectomy,

were sent a questionnaire (Q1) to assess their suitability for tonsillectomy (see Appendix A). A letter was also sent to the GP to inform them that the patient would be receiving a tonsillectomy questionnaire leaflet. This questionnaire consisted of eight parts designed to assess if the patient met the criteria for tonsillectomy, if they were medically fit for surgery and to exclude any patients in whom tonsillectomy would be contraindicated.

Part 2: Patient selection

The returned questionnaires were reviewed by the consultant otolaryngologist and patients that fulfilled the criteria for tonsillectomy were booked for the procedure. Once booked for tonsillectomy, a leaflet regarding the procedure, including the risks and complications was sent to the patients (Appendix B). Patients or parents of underage patients were required to read, sign and return this leaflet to confirm that they had fully understood the procedure. The patient's name was placed on the waiting list for tonsillectomy on receipt of this leaflet.

Patients that did not fulfil the criteria for tonsillectomy based on the questionnaire review, or patients with medical conditions that required further assessment were sent an outpatient appointment and therefore excluded from the 'direct booking system'.

Part 3: (Assessment of knowledge)

On the day of admission for tonsillectomy, the patient or parents of an underage patient were assessed by an otolaryngology registrar, who was blinded as to whether the patient was booked for surgery via the traditional outpatient review or via the direct booking system. A further questionnaire consisting of four parts, designed to assess patients or parents' knowledge of the procedure, recovery period, risks and complications of the procedure and risks of anaesthesia was completed. Score 0 was given for zero knowledge, 1 for minimal knowledge, 2 for good knowledge and 3 for excellent knowledge. The maximum possible score was 54.

After thorough questioning and clinical examination, the patient or parents were asked to sign the routine consent form prior to the surgery.

Assessment of waiting time

The length of delay (date of referral by general practitioner to the time of surgery) was calculated (months).

This study was ethically approved by the Ethics committee of Beaumont Hospital Dublin, Ireland.

Results

In total 42 patients were included in this study. 22 patients were booked for tonsillectomy through the traditional outpatient method while 20 patients were booked via the direct booking system (Table 1). 7 patients that were initially sent questionnaire 1 as part of direct booking patients were excluded after the consultant reviewed their returned questionnaire. These patients were sent outpatient appointments. There were 20 female patients and 22 male patients.

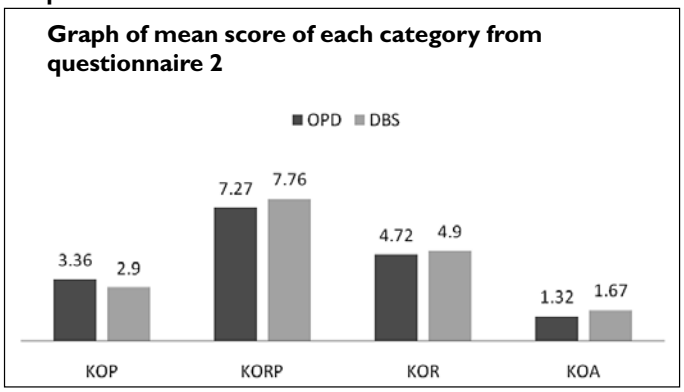
Table 1

	Overall	Outpatient	Direct booking
Number of patients	43	22	21
Female: male	20:23	8:14	12:9
Mean age	9.53 (3–23)	7.36 (3–13)	11.81 (3–23)
Child:adult	37:6	20:0	15:6

The ratio of child to adult patients was 36 to 6. All patients booked through the outpatient clinic were below the age of 15, while 16 children and 6 adults were booked through the direct booking system. The mean patient age was 9.53 years (range 3 to 23 years).

We calculated the mean score overall, and within each category in questionnaire 2, to assess and compare patients' and parents' knowledge of tonsillectomy (Graph 1). The mean overall score was 16.31 (SD=5.51), the mean score of patients booked through the outpatient clinic was 16.68 (SD=6.42) and the mean score of those patients booked through the direct booking system was 17.05 (SD=4.52). There was no statistical significance between the groups (*P*-value =0.8307). 95% confidence interval of this difference is -3.80 to 3.07 and the standard error of difference equals 1.70.

Graph 1



The mean waiting time between GP referral to surgery was 12.8 months (standard deviation=2.97) (range between 8 to 18 months) in the group seen in the outpatient clinic, and 5.4 months (standard deviation=1.14) (range between 4 to 7 months) in the direct booking system group. This result is statistically significant (*P*-value less than 0.0001).

Discussion

Currently our system is unable to cope with the volume of referrals for routine ENT assessment resulting in waiting times of up to 18 months. These prolonged waiting times for an appointment are due to lack of manpower to assess the individual cases.

The idea of a direct booking system grew from our experiences of dealing with referrals through the traditional outpatient channel and publications from the UK concerning direct access surgery in general, direct access day case oral surgery, direct access hernia referral and direct access colposcopy clinics [2,3,4,5,6]. To date our results show a significant improvement in the patient waiting time from an average of 12.8 months (range 8 to 18 months) to 5.4 months (range 4 to 7 months) and hence we have taken a big step forward in achieving our goal to release the backlog and pressure from our system, thus dramatically improving individual patient waiting time for specialist management and hence protecting the welfare of patients.

The direct booking system also allows us to manage patients more cost effectively, as there are a lot less contributing cost components. The following is a simple illustration to show cost comparison between the two groups.

The outpatient group journey through the system is far more complex and detailed and incurs accumulative costs along the way, i.e. travelling expenses to and from the hospital, lost time at work, doctors, nurses and secretary fees, stationary and equipment maintenance costs. Based on an average consultation time of 10 minutes, coupled with outpatient waiting time of 30 minutes and including all or some of the above ingredients an average cost for the

outpatient group has a range from approximately 80 to 140 Euros per patient.

We compared this with the direct booking system group, which incurs less cost as there are less contributing factors. This system simply requires consultant administrative time of approximately 5 minutes coupled with stationery and postage costs. Based on these criteria, we have calculated an average cost to be in the region of 10 Euros.

Tonsillectomy was chosen, as opposed to other procedures, because patient selection for this procedure is based on standard criteria and patient history. Patient' examination is rarely a consideration. The direct booking system has an inbuilt safety measure in that a senior member of the team reviews the patient on admission, goes through their questionnaire in detail, ensures all information was accurate and still pertinent, ensures that the surgery is warranted, that there is no reason not to proceed and that the patient is fully consented. If at any point it is not deemed safe or correct to proceed the patient is seen by the senior author and the procedure cancelled or deferred as appropriate.

It was interesting to note that the level of knowledge about the procedure and its risks and complications, of both patients and parents was found to be inadequate. Both groups scored an average of below 20 (16.68 by outpatients group, and 17.05 by direct booking group). The patients in the direct booking group had been sent a detailed leaflet regarding all aspects of tonsillectomy, once the decision had been made that they were suitable for surgery. There is an inherent risk with this practice that the patient will either not have the reading skills or comprehension to follow the content of the information sheet, or may in some cases fail to make any attempt to read it. However, we were interested to note that patients in this group were somewhat better informed than those patients who had had a traditional consultation in the outpatient clinic. The latter group would have been informed face to face of the options risks and complications of surgery and would have had the opportunity to ask for further clarification as required. Thus, despite oral and written advice both of our patient groups were poorly informed regarding the procedure they were about to undergo.

Table 2

	Overall (mean score)	Outpatient (mean score)	Direct booking (mean score)
Knowledge of procedure (n=9)	3.14(0–7)	3.36(0–7)	2.90(0–6)
Knowledge of recovery period (n=15)	7.51(4–15)	7.27(4–14)	7.76(4–15)
Knowledge of risk (n=24)	4.81(1–18)	4.72(1–18)	4.90(3–10)
Knowledge of risks of anaesthesia (n=6)	1.48(0–4)	1.32(0–4)	1.67(0–6)

Conclusion

The direct booking system for a tonsillectomy service provides an efficient and safe way of managing patients referred by general practitioners. It significantly reduces the waiting time from GP referral to surgery and successfully reduces the burden on the outpatient department.

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Appendix A

Part 1: Patient Selection

1) How long have you been suffering from sore throats?

- Weeks ☐
- Months ☐
- Years ☐

2) How often do you get sore throats?

- One per month ☐
- One per 2 months ☐
- One per 3 months ☐
- More than 2 per month ☐

3) How long do these sore throats last?

- Less than 48 hours ☐
- 2–3 days ☐
- Greater than 3 days ☐

4) When you have your sore throats, do you:

- Have high fever?
- Do the glands in your neck enlarge?
- See pus on the surface of the tonsils?
- Suffer from prolonged tiredness and lack of energy following the sore throats?
- Ever develop a rash associated with the sore throats?

5) Have you ever missed some time from school or work because of these sore throats?

6) Have you ever been admitted to the casualty department or hospital because of a severe sore throat

7) Have you ever had quinsy or peritonsillar abscess?

8) Are these sore throats significantly affecting your quality of life?

Part 2: General Health

Do you suffer from any of these symptoms?

1) Chronic nasal discharge? ☐
2) Recurring ear infection? ☐
3) Loud snoring? ☐
4) If yes, do you suffer from day time tiredness? ☐
5) Have you any drug allergies? ☐
6) Have you any tendencies to bleed or bruise easily ☐
7) Have you aver been diagnosed with heart murmurs? ☐
8) Have you ever been diagnosed with heart murmur? ☐
9) Have you had any general anaesthetic in the past? ☐
10) If so, did you develop any complications? ☐
11) Is there a family history of problems with anaesthesia? ☐

12) Are you on any of these medications?

- a. Contraceptive pills ☐
- b. Aspirin ☐
- c. Plavix ☐
- d. Warfarin ☐
- e. Lithium ☐
- f. MAOI inhibitors ☐

13) Do you suffer from:

- a. Rheumatic heart disease ☐
- b. Kidney disease ☐
- c. Psoriasis ☐

14) Do you have any dental implants, dental bridge, caps or brace?

Appendix B

Department of Otorhinolaryngology, Head and Neck Surgery
Beaumont Hospital

Pre Operative Information – Tonsillectomy

The procedure you have been booked for is called Tonsillectomy. It involves removal of the tonsils/ adenoids under general anaesthesia. The aim of the procedure is to prevent recurrent tonsillitis (sore throats).

The procedure involves a hospital stay of approx 2 days. The procedure is performed under general anaesthesia.

There are a number of possible risks involved in having this procedure. These include the following:

1) Post operative pain:

Regular pain relieving medication is prescribed for the post operative period. This is necessary to allow each patient to proceed with a normal diet. The resumption of a normal diet following surgery is a crucial part of the healing process.

2) Infection

This may occur following the procedure, and may cause increasing pain. An antibiotic may be prescribed if this is suspected.

3) Bleeding

This may occur following the procedure (within 24 hours) or up to 15 days after the surgery, and if severe may necessitate readmission to hospital, blood transfusion, or a further procedure under anaesthesia to stop the bleeding.

Rare complications:

Anaesthetic complications – anaesthetic complications are very rare but can be serious.

Minor complications include nausea and vomiting

Problems which may occur if no surgery performed:

- The disease process of recurrent tonsillitis itself, if left untreated can cause a number of complications:
- Recurrent tonsillitis may necessitate the frequent and repeated use on antibiotics.
- Rarely infections are associated with heart disease, kidney disease or skin disease.
- In young children this can lead to failure to thrive- with poor weight gain etc.
- Frequent infections may lead to time being missed from school/ work.
- This leaflet has been produced to provide you with all the information you may require regarding your scheduled surgery. If you have any further questions, or wish to clarify any issue raised here please contact any member of the ENT team who will be happy to deal with your enquiry.

Please sign below to confirm that you have read and understood the above information.

Patients/ parents signature: _____

Print name:_____ _____

Appendix C

QUESTIONNAIRE 2 (Q2)

PATIENT MRN: _____

DATE OF BIRTH: _____

GENDER: _____

1. Knowledge of procedure (KOP)

- Under GA _____
- Use of Tonsil Gag _____
- Method to secure bleeding _____

2. Knowledge of recovery period (KORP)

- Referred otalgia _____
- Importance of oral intake _____
- Method of pain relief _____
- Length of stay _____
- Presence of slough on tonsils _____

3. Knowledge of Risks (KOR)

- Primary Haemorrhage _____
- Secondary Haemorrhage _____
- Ear infection _____
- Chest infection _____
- Damage to teeth _____
- TMJ problem _____
- Persistent pain _____
- Recurrence of tonsils _____

4. Knowledge of risks of anaesthesia (KOA)

- Allergy _____
- Nausea/vomiting _____

0 = no knowledge

1 = minimal

2 = good

3 = excellent

Total score: _____/____54_____

Clinical indicators for ambulatory surgery

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Abstract

14 clinical indicators for ambulatory surgery were tested on a sample of 111.374 complete AQS1-questionnaires from 1000 surgical units in the fields of gynaecology, orthopaedics and general surgery during a period of 3 years. In addition benchmarking was visualized in 12 different surgical units after "arthroscopic cruciate ligament reconstruction". The results show that there is enough variation between different surgical units so that this can be used for the staff of surgical units as a tool for self-learning and improving process management. The results also can help to prepare patients for what they have to encounter in ambulatory surgery.

Keywords: Clinical indicator; Ambulatory surgery; Benchmarking

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Aim

The aim is to update the results of the quality assurance programme AQS1 with respect to selected clinical indicators (CI). In particular, this study should answer the question what CI can be used to measure differences in the quality outcome with respect to the different specialties, surgical procedures and surgical units.

History

In 1999 the Bundesverband für Ambulantes Operieren (BAO) in cooperation with medicaltex GmbH, a private firm specializing in quality assurance programmes for surgery, started an assurance program AQS1 for ambulatory surgery in Germany. This comprised 3 questionnaires, one for the surgeon, one for the anaesthetist and a third and separate one for the patient [1].

In 2007 after evaluating the data of more than 200 000 procedures we suggested to the National Association of SHI-Accredited Physicians (Kassenärztliche Bundesvereinigung KBV) 16 indicators to monitor quality in ambulatory surgery in Germany [2]. Fourteen of these indicators were used for the present study. So far the government has not yet decided upon a national quality assurance programme. But the Kassenärztliche Vereinigung Bayerns (KBV), representation of the KBV in Bavaria, and the BAO together issued a positional paper endorsing the quality assurance programme AQS1 after having studied two clinical indicators in co-operation with the Ludwig-Maximilians-University of Munich [3].

Methods

The quality assurance programme AQS1 was described in detail [4].

By the end of 2009, data on more than 500.000 ambulatory surgical procedures from about 1.000 surgical units (doctors' offices and day clinics, all government licenced for ambulatory surgery) were available for assessment. The return rate of the patient questionnaires was 50% overall. The collected data comprised all surgical fields. Most data (about two third of the patients) were provided by the three specialties gynaecology, orthopaedic surgery and general surgery.

14 clinical indicators were evaluated for this study. They are:

1. Unplanned hospitalisation within 14 days
2. Waiting time from time appointed for surgical procedure up to actual beginning
3. OR blocking time (from arrival of patient in the OR until leaving)
4. Time period in the recovery area
5. Inability to work (in days) after surgery
6. Intensity of wound pain on the 1st. post-operative day
7. Intensity of nausea on the 1st. post-operative day
8. Possibility to reach the surgeon or anaesthetist at any time
9. Necessity after discharge to see another doctor as an emergency case
10. Sufficient pain medication on the day of surgery (pain scale)
11. Complication "wound infection" requiring treatment
12. Complication "thrombosis" requiring treatment
13. Complication "post-operative bleeding" requiring treatment
14. Satisfaction with this ambulatory procedure

For this evaluation we used a sample of 111.374 complete AQS1-questionnaires that were documented between January 2007 and December 2009, i.e. a period of 3 years.

We chose several groups to test the clinical indicators. The first group represented the entire collective, the second the specialty "gynaecology" and the third group the specialty "orthopaedic surgery". The fourth group consisted of twelve day clinics which performed the procedure "arthroscopic cruciate ligament reconstruction" on at least 50 patients in the selected time period.

Results

1. Clinical indicators for the entire collective

The average waiting period from time appointed for surgery up to the actual beginning called "unplanned waiting time" was 37 minutes. The "OR blocking time" (from arrival of patient in the OR until leaving) was 49 minutes and the time period in the recovery area ("recovery period") was 109 minutes. The average "period of disability" after surgery in the entire collective was 10 days.

On the first post-operative day 6,8 % of all patients marked the question "intensity of wound pain" as "severe" and 2,8 % had "severe" problems with nausea.

Table 1 shows the percentage of the patients feedback with respect to some particular clinical indicators. The result "complication wound infection requiring treatment" means, that at least antibiotics were taken by the patient, "complication post-operative bleeding requiring treatment" means that the patient was at least treated with a salve bandage.

Only 1,7 % of all patients had to be admitted to a hospital after ambulatory surgery. The wound infection rate was 2,7 % and 98,1 % of the patients would be happy to have ambulatory surgery again.

Table 1 Selected clinical indicators in the judgement of patients (entire collective) (AQS1- study 2010, n= 111.374 patient questionnaires)

Clinical indicator	Yes	
Sufficient pain medication on the day of surgery	96,3%	3,7%
Possibility to reach the surgeon or anaesthetist at any time	91,6%	8,4%
Necessity to see another doctor as an emergency case after discharge	1,5%	98,5%
Unplanned hospitalisation after ambulatory surgery	1,7%	98,3%
Complication "wound infection" requiring treatment	2,6%	97,4%
Complication "thrombosis" requiring treatment	0,7%	99,3%
Complication "post-operative bleeding" requiring treatment	5,6%	94,4%
Patient would decide for ambulatory procedure again	98,1%	1,9%

2. Clinical indicators for gynaecology

The average "unplanned waiting time" was 36 minutes. The "OR blocking time" was 52 minutes and the "recovery period" was 108 minutes. The average period of disability was 17 days.

6,3 % of all patients reported "severe" intensity of wound pain on the first post-operative day. 3,4 % had "severe" problems with nausea.

Table 2 shows the percentage of patients feedback with respect to the particular clinical indicator.

Unplanned hospitalisation after ambulatory surgery was only 1,5 %. Patient satisfaction was 98,4 %.

3. Clinical indicators in orthopaedic surgery

The average "unplanned waiting time" was 37 minutes, the "OR blocking time" 49 minutes and the "recovery period" was 109 minutes. The period of disability was 10 days.

6,9 % of all patients had a "severe" intensity of wound pain on the first post-operative day. 2,6 % had "severe" problems with nausea.

Table 3 shows the judgement of the patients with respect to particular clinical indicators. Orthopaedic surgery showed similar results to gynaecological surgery with low rates of unplanned hospitalisation (1,1 %) and overall good satisfaction of patients (97,7 %).

Table 2 Judgement of gynaecological patients concerning clinical indicators (AQS1- study 2010, n= 35.630 patient questionnaires)

Clinical indicator	Yes	No
Sufficient pain medication on the day of surgery	94,7%	5,3%
Possibility to reach the surgeon or anaesthetist at any time	91,2%	8,8%
Necessity to see another doctor as an emergency case after discharge	1,7%	98,3%
Unplanned hospitalisation after ambulatory surgery	1,5%	98,5%
Complication "wound infection" requiring treatment	2,7%	97,3%
Complication "thrombosis" requiring treatment	0,3%	99,7%
Complication "post-operative bleeding" requiring treatment	3,6%	96,4%
Patient would decide for ambulatory procedure again	98,4%	1,6%

Table 3 Clinical indicators in orthopaedic surgery - the patient´s judgement (AQS1-study 2010, n= 36.733 patient questionnaires)

Clinical indicator	Yes	No
Sufficient pain medication on the day of surgery	98,1%	1,9%
Possibility to reach the surgeon or anaesthetist at any time	93,0%	7,0%
Necessity to see another doctor as an emergency case after discharge	1,4%	98,6%
Unplanned hospitalisation after ambulatory surgery	1,1%	98,9%
Complication "wound infection" requiring treatment	2,0%	98,0%
Complication "thrombosis" requiring treatment	1,2%	98,8%
Complication "post-operative bleeding" requiring treatment	7,2%	92,8%
Patient would decide for ambulatory procedure again	97,7%	2,3%

4. Clinical indicators for the orthopaedic procedure "arthroscopic cruciate ligament reconstruction"

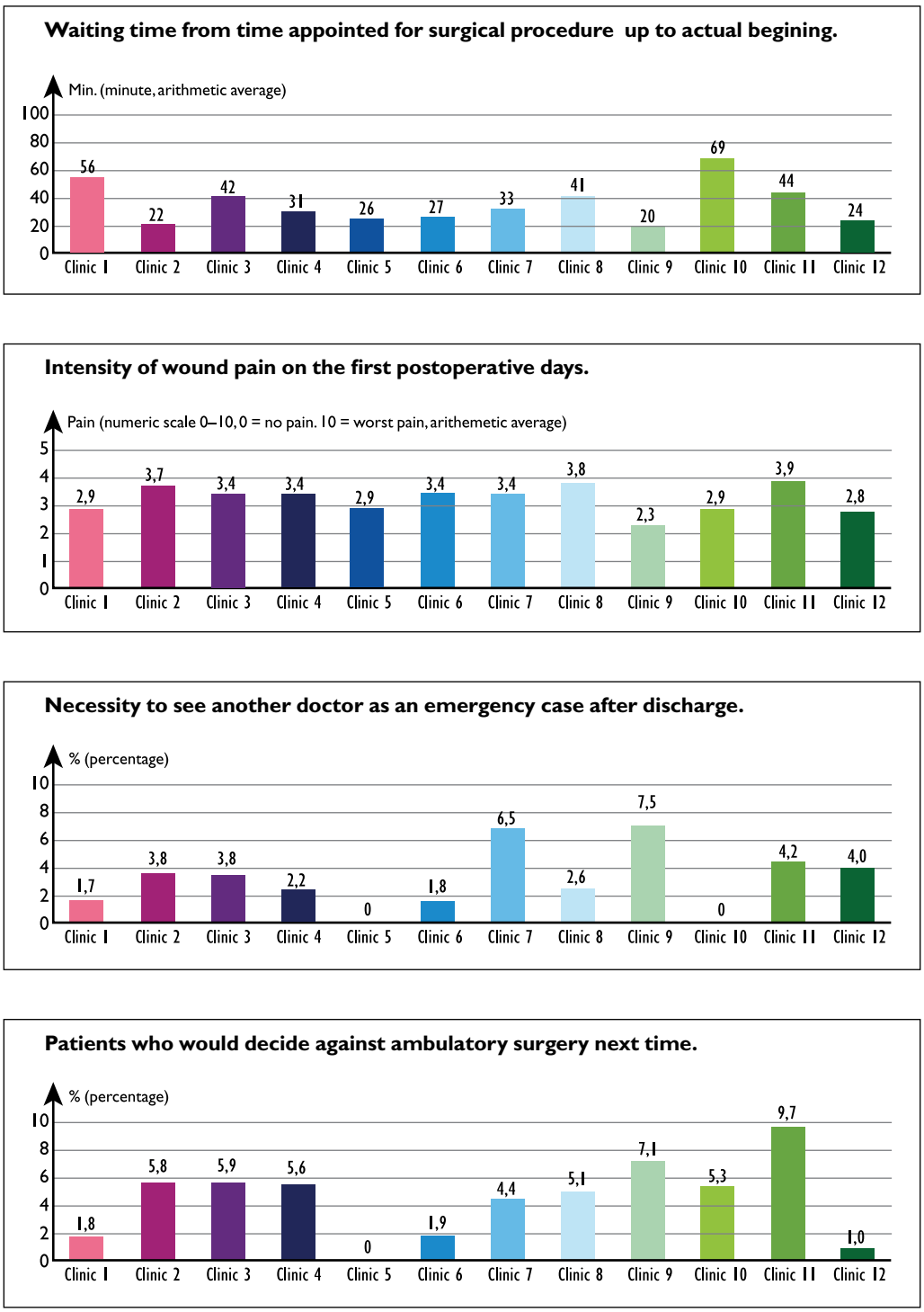
Figure 1 shows the results of 12 different day clinics and their performances with respect to 4 clinical indicators:

1. Unplanned waiting time, 2. Intensity of wound pain, 3. Necessity to see another doctor, 4. Patient dissatisfied with ambulatory surgery.

The results were:

- "Unplanned waiting time" in the 12 different day clinics ranged between 0 and 60 minutes.
- "Intensity of wound pain" on the first post-operative day was judged to be between 0 and 3,9 on a pain scale of 10.
- "Necessity to see another doctor" as an emergency case after discharge occurred between 0 and 7,5 % of all patients.

Fig. 1 Benchmarking for 12 different day clinics using 4 clinical indicators after 'arthroscopic cruciate ligament reconstruction'. (AQS1-study, n = 2,525 patient questionnaires)



- Between 0 and 9,7 % of the patients would decide against an ambulatory procedures the next time.

Thus there is marked variation between the different day clinics

Conclusion

The selected clinical indicators obviously allow benchmarking between individual day clinics and the collective which at the end of 2009 comprised 1000 surgical units.

The benchmarking reports – issued quarterly – indicates to surgeons and anaesthetists where to improve their process management and thus the wellbeing of their patients. Thus AQS1 initiates and sustains a process of self-learning which has been documented in special cases.

For potential patients the results of this assurance programme offer solid evidence how well former patients have felt after ambulatory surgery in the whole collective and in particular in specific day clinics.

Our results also show that there is a substantial variation between the surgical specialties on the one hand and between different day clinics where the same surgical procedures were performed.

We can conclude that our selected indicators are appropriate to indicate quality differences in ambulatory surgery.

For future aspects these clinical indicators can be evaluated with respect to economic efficiency, i.e. inability to work, and to patient satisfaction.

The questionnaires can be filled out within minutes during routine work. The cost for one AQS1-questionnaire inclusive of the return postage for the patient is 1,49 € for the print version and 1,41 € for the online version.

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Effect of Outpatient Bowel Preparation On Preoperative Electrolytes

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Abstract

Study Objective: With the shift to outpatient and same-day admit surgery, preoperative bowel preparation is now also performed on an outpatient basis. This practise has the potential to cause electrolyte disturbances and for this reason, patients have their electrolytes re-measured on the day of surgery in order to detect and rectify any abnormalities. Though the ability to do this on an outpatient basis has been studied, to our knowledge the effect on preoperative bloodwork has not been documented and was our goal.

Design: A retrospective observational analysis of charts of patients 18 years of age and older, who underwent outpatient bowel preparation for an elective bowel resection in 2006.

Setting: The Perioperative services of two sites of a tertiary care institution.

Patients: Medical records identified 119 patients who met the specified inclusion criteria.

Interventions: Patients that had both preadmission (PAC) and day of surgery (DOS) bloodwork obtained (standard practise) were reviewed and regression analysis performed.

Measurements: Serum chemistry (sodium, potassium, chloride, bicarbonate, creatinine, blood, urea, nitrogen and haemoglobin) were noted in the PAC and on DOS as well as their demographic data including comorbidities.

Main Results: There was a statistically significant decrease in chloride, bicarbonate, potassium (K+) and blood urea nitrogen (BUN) and an increase of creatinine (Cr). There were 9 patients whose K+ was < 3.0 on DOS that had been > 3.0 in PAC and 13 patients whose creatinine was >100 on DOS that had been <100 in PAC. No correlation between demographic factors (including age, gender, type of bowel preparation or comorbidity) and day of surgery hypokalemia or elevated creatinine were noted.

Conclusions: We documented statistically significant but clinically insignificant changes in potassium, chloride, bicarbonate, BUN and creatinine. There were no predictive factors for either hypokalemia or elevated creatinine. No changes in patient management occurred. There appears to be no value in repeating serum chemistries after bowel preparation performed at home.

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Introduction

Prior to undergoing an elective bowel resection, patients receive a bowel preparation to clean out the normal intestinal bacteria flora. This bowel preparation is performed to minimize potential surgical infectious complications. In the past, this practise was performed on an inpatient basis with concomitant intravenous rehydration. With the shift to outpatient surgery, this bowel preparation must now also be performed on an outpatient basis. The feasibility and general safety of this has been studied though the effect on serum biochemistry was not documented [1–4]. Concurrent with this change in practise was a change from obtaining routine bloodwork in all patients to only testing those patients likely to have expected abnormalities [5–7]. These bowel preparations have the potential to cause electrolyte abnormalities especially in elderly patients [8–11]. For this reason, patients have their electrolytes re-measured on the day of surgery in order to detect and rectify any abnormalities. It was our impression that rarely however, are any abnormalities detected and to our knowledge the effects on serum biochemistry of outpatient preoperative bowel preparations has not been studied. The goal of this study was therefore to determine if repeat day of surgery (DOS) blood work was necessary. If changes are minimal or non-existent, patients are needlessly receiving phlebotomies and the medical system is wasting money on unnecessary laboratory testing.

Materials and Methods

Following research ethics board (REB) approval we performed a retrospective, observational analysis of the charts of patients who underwent outpatient bowel preparation for an elective bowel resection in 2006 at two sites of a tertiary care institution. Written informed consent was not deemed necessary by the REB. Patients were included if they were 18 years of age and older and had both preadmission (PAC) and day of surgery (DOS) blood work obtained (which is standard practise at our institution). Patients not having DOS bloodwork, those having emergency surgery or those who were inpatients prior to the procedure were excluded. Demographic data, coexisting medications and diseases, the type, timing and amount of bowel preparation as well as preadmission clinic and then day of surgery bloodwork were recorded.

Statistical analysis included paired t-tests to compare PAC and DOS lab results and chi-squared analysis for demographic data. Multiple logistic regression was used to determine if there were any predictive factors (age, type of bowel preparation, gender, coexisting disease, use of diuretic) for patients who developed hypokalemia, defined as a potassium (K+) < 3.0 or elevated creatinine (Cr), defined as > 100 after having normal PAC bloodwork. A p value < 0.05 was considered significant.

Results

Our hospital mmedical records department identified 119 patients who met the specified inclusion criteria. The demographic data of these patients are shown in Table 1. Table 2 compares the preadmission clinic and day of surgery bloodwork data. There was a statistically significant decrease in bicarbonate, potassium and BUN and an increase of chloride and creatinine as shown.

Table 1 Demographic Data – All Patients. Values are n (%) except age – mean ± SD.

Age	65.0 ± 14.6
Gender (M/F)	52/67
Procedure	
Colectomy	81 (68)
Colectomy + Other general surgery	23 (19)
Colectomy + Other gynaecologic/ genitourinary	15 (13)
Bowel Preparation	
Sodium picosulfate po	43 (36)
Sodium phosphate po	67 (56)
Clear fluids only	5 (4.2)
Polyethylene glycol po	4 (3.4)
Comorbidities	
Bowel cancer	76 (64)
Gynecologic cancer	6 (5)
Inflammatory bowel disease	50 (42)
Cardiovascular	59 (50)
Metabolic	29 (24)
Respiratory	20 (17)
Renal	4 (3.4)
Cerebrovascular	10 (8.4)

Table 2 Comparison of Preadmission Clinic (PAC) & Day of Surgery (DOS) blood work. Values are mean ± SD.

	PAC	Day OR	P Value
Na+	138.6 ± 2.0	138.9 ±2.5	0.38
Cl-	101.6 ± 3.4	102.8 ±3.9	< .001
HCO3-	28.2 ± 2.0	26.6 ± 2.7	< .001
K+	4.0 ± 0.4	3.9 ± 0.5	< .001
BUN	4.8 ± 1.9	1.2 ±1.2	< .001
Cr	84.9 ± 20.5	91.3 ± 24.7	< .001
Hgb	127 ± 23	120 ± 21	0.67

Table 3 Demographic Data – Patients DOS K < 3.0 (n=9). Values are n (%) except age – mean ± SD.

Age	77.1 ± 7.0
Gender (M/F)	1/8
Procedure	
Colectomy	5 (56)
Colectomy + Other general surgery	1 (11)
Colectomy + Other gynaecologic/ genitourinary	3 (33)
Bowel Preparation	
Sodium picosulfate po	2 (22)
Sodium phosphate po	6 (66)
Clear fluids only	1 (11)
Polyethylene glycol po	0
Comorbidities	
Bowel cancer	6 (66)
Gynecologic cancer	1 (11)
Inflammatory bowel disease	2 (22)
Cardiovascular	8 (89)
Metabolic	3 (33)
Respiratory	4 (44)
Renal	0
Cerebrovascular	0

Table 3 Demographic data – Patients DOS CR > 100 (n=13). Values are n (%) except age – mean ± SD.

Age	62.5 ± 18.0
Gender (M/F)	6/7
Procedure	
Colectomy	7 (54)
Colectomy + Other general surgery	3 (23)
Colectomy + Other gynaecologic/ genitourinary	3 (23)
Bowel Preparation	
Sodium picosulfate po	4 (31)
Sodium phosphate po	8 (62)
Clear fluids only	1 (7.7)
Polyethylene glycol po	0
Comorbidities	
Bowel cancer	5 (38)
Gynecologic cancer	1 (7.7)
Inflammatory bowel disease	10 (77)
Cardiovascular	6 (46)
Metabolic	6 (46)
Respiratory	1 (7.7)
Renal	1 (7.7)
Cerebrovascular	1 (7.7)

There were 9 patients whose K+ was < 3.0 on DOS that had been > 3.0 in PAC and 13 patients whose creatinine was > 100 on DOS that had been < 100. Their demographic data is shown in Tables 3 and 4. No correlation between demographic factors (including age, gender, type of bowel preparation or comorbidity) and day of surgery hypokalemia defined as K < 3.0 or elevated creatinine defined as Cr > 100 were noted. The lowest preoperative K+ was 2.3 in a patient whose PAC K+ was 5.1. This patient was 74 years old, with coexisting cardiac and respiratory disease but was not taking a diuretic. The surgery proceeded as planned and the first postoperative K+ was 4.4, later on the day of surgery. The highest preoperative Cr was 176 in a patient whose PAC Cr was 84. This patient was 60 years old with coexisting cardiac, metabolic and cerebrovascular disease and was also not taking a diuretic. A review of the charts indicated that there appeared to be no change in management of either of these cases.

Discussion

We documented statistically significant changes in potassium, chloride, bicarbonate, BUN and creatinine in patients having outpatient bowel preparation for bowel resection either alone or in conjunction with urologic or gynecologic surgery. These changes were however clinically insignificant. More significant electrolyte changes were found in a previous study by Holte [8]. However that study involved elderly inpatients, a group who by definition have more medical comorbidities than the elective surgical patients being admitted from home in our study.

Nine patients developed hypokalemia defined as a K+ < 3.0 and 13 patients developed creatinine > 100 the latter of which suggests dehydration or pre-renal syndrome. There was however no evidence that any change in clinical management had occurred, which also questions the need to repeat bloodwork in these patients. In an attempt to determine if a subset of patients existed that would warrant repeat testing, we performed multiple logistic regressions. However there were no predictive factors for hypokalemia and elevated creatinine. Specifically, age and coexisting disease were not correlated with these changes and the biggest rise in creatinine occurred in a 60 year old who was not on a diuretic as was the patient with the lowest K+.

Our institution initiated the repeat DOS blood sampling based on the suggestion of the ASA practise parameter that notes one should consider biochemical testing in patients undergoing perioperative therapies which we felt would include bowel preparation [5]. This testing would also fall under the British NICE guideline of group 4 surgeries which recommends a similar assessment [6]. These guidelines were however created with the acknowledgment that they are not evidence based.

Bowel preparations at our institution were not standardized and consisted of various combinations and doses of sodium picosulphate, sodium phosphate or polyethelene glycol enemas, or simply clear fluids for 24–48 hours. The majority of our patients however received either oral sodium picosulphate or sodium phosphate preparations. A recent study showed that both of these regimens to produce electrolyte abnormalities in a similar patient population when measured intra or postoperatively though no preoperative bloodwork was performed [8]. However, by this time in the procedure the patients had likely sustained further fluid losses and rehydration efforts making the results non-comparable to ours. Studies have noted clinically significant abnormalities after more aggressive bowel cleaning regimens in volunteers [9], or in hospitalized inpatients [10], or in case reports of similar patients with comorbidities [12]. In these studies and case reports the patients or the bowel preparations were clearly different than the elective outpatients we studied.

Our study's major weakness is its retrospective design. As such, patient's who had significant electrolyte abnormalities could have had their surgery postponed until corrected and would not have been included in our analysis. One could also question the validity of the lack of standardization of both the bowel preparation and the fluid intake of patients. The corollary is that our study's results reflect the conditions present in hospitals with more than one surgeon whose bowel preparation practises are not standardized.

In conclusion our findings question the need for repeating phlebotomy for electrolyte analysis on the day of surgery for patients having an outpatient bowel preparation. Although statistically significant abnormalities were noted they are clearly clinically insignificant and did not lead to changes in patient management.

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Carbon dioxide pneumoperitoneum, physiologic changes and anesthetic concerns

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Abstract

Objective: To review the different changes in physiology during carbon dioxide pneumoperitoneum, and the necessary adjustments to minimize and manage them.

Data sources: Data were obtained from searches in PubMed years 1997 to 2009, using key words: laparoscopy and anesthesia, effects of pneumoperitoneum on cardiovascular system, pneumoperitoneum and respiratory system, renal perfusion during laparoscopy.

Results: Many physiological changes occur during CO_2 pneumoperitoneum. The severity of these changes depends on the intra-abdominal pressure being used, and also the position of the patient on the operating table plays an important role. With adequate adjustments and pharmacologic therapy, many of these alterations can be safely managed and prevented.

Conclusion: A thorough understanding of the pathophysiology which occurs during carbon dioxide intra-abdominal insufflation is mandatory to manage promptly any complications that arise. Anesthetists and surgeons should also put much emphasis on ways and techniques to reduce these alterations, therefore reducing patients' exposure to complications that might follow.

Keywords: Pneumoperitoneum; Elevated abdominal pressure; Insufflation; Hypercarbia; Desufflation; Cardiac output

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Introduction

Laparoscopic surgery is nowadays a common daily-performed procedure worldwide, replacing many types of open surgeries. It has the benefits of small incision, improved cosmetic aspects, less postoperative pain, and quick recovery time to normal activities [1, 2]. The most commonly used gas for insufflation is carbon dioxide. Carbon dioxide CO_2 pneumoperitoneum and increased intra-abdominal pressure can induce many pathophysiologic disturbances, requiring the anesthesiologist to be well alert during the operation for necessary management. Moreover, advanced laparoscopic surgeries are being used also on older patients and in critically ill patients, requiring technically demanding anesthesia.

Pathophysiologic changes

Respiratory changes

The physiology of respiratory system is affected by pneumoperitoneum. With insufflation, causing an increase in intra-abdominal pressure (IAP), the diaphragm is pushed upwards causing stiffness of the chest wall, causing the total volume of the lungs to be reduced. Hence the pulmonary compliance is decreased to 35–40% and also a non-negligible increase in the maximum respiratory system resistance [3, 4, 5, 6]. Hypoxemia may occur from a ventilation-perfusion mismatch and intrapulmonary shunting [7] but is rare in healthy patients.

Carbon dioxide is usually administered at a rate of 1–2 ml/min. Being a highly soluble gas, it is readily absorbed into the circulation through the peritoneum, causing hypercapnia and acidosis. Several studies have shown the effect of CO_2 pneumoperitoneum on the arterial partial pressure of CO_2 ($PaCO_2$) and end-tidal CO_2 ($ETCO_2$). One study has compared laparoscopic Roux-en-Y gastric bypass (GBP) against open surgery. It found that $ETCO_2$ was raised from 35 mmHg to 40 mmHg, i.e. by 14%, whereas PaCOv also was raised by 10%, from 38 mmHg to 42 mmHg [8]. $PaCO_2$ levels were initially 34 mmHg and increased to 42 mmHg with pneumoperitoneum as reported by Demiroluk and al [9]. Wittgen et al [10] found that patients with normal cardio-respiratory system had increased $ETCO_2$ and PaCOv, decreased pHa values in a study comparing ventilatory effects of laparoscopic cholecystectomy in 10 ASA I and II patients and in 10 ASA III and IV patients. However, changes were more pronounced in the ASA III and IV patients.

Carbon dioxide is mainly excreted by the lungs, depending on alveolar and mixed venous CO_2 exchange rates, which are themselves controlled by the cardiac output, alveolar ventilation and respiratory quotient [11]. Normal excretion of CO_2 is 100–200 mL/min and is increased by 14–48 mL/min when CO2 is administered intraperitoneally [12, 13, 14, 15]. After a long laparoscopic operation, achieving a normal CO_2 value can take several hours after desufflation, [16, 17] since high use of peripheral storage capacity will lengthen the duration of increased $PaCO_2$.

Cardiovascular changes

Cardiovascular system effects during CO_2 pneumoperitoneum are caused mainly by hypercarbia followed by acidosis and increased intra-abdominal pressure. A euvolemic status is of great importance prior to surgery to reduce any cardiac depression via reduced

preload caused by the pneumoperitoneum. Hypercarbia has direct and indirect sympathoadrenal stimulating effects on cardiovascular functions. These effects are not pronounced with mild hypercarbia ($PaCO_2$ 45–50 mmHg), whereas moderate to severe hypercarbia affects cardiac function [18] since it is then a myocardial depressant and has direct vasodilatary effect. Dexter et al [19] studied 2 groups of patients, one with pneumoperitoneum of 7 mmHg and the other with a pressure of 15 mmHg. Both groups showed an increase in heart rate and mean arterial pressure, but the cardiac output and stroke volume were more considerable depressed in the 15 mmHg group. Westerban et al [20] studies showed a 30% decrease of cardiac index in patients during laparoscopic cholecystectomy. Kraut et al [21] showed a mild decrease in cardiac output and stroke volume using insufflation pressure of 15 mmHg. The addition of 10 cm of PEEP resulted in significantly reduced cardiac output and stroke index. Those authors therefore concluded that combination of increased IAP and PEEP should be avoided. With a post-inflation IAP of 15 mmHg, Joris et al [22] showed a mean arterial pressure increase of 35%, systemic vascular resistance increase of 65%, pulmonary vascular resistance increase by 90%, and a decrease in cardiac index by 20%. The authors suggested that increased vascular resistance could partly increase the cardiac index.

Renal changes

Oliguria is the most common renal effect of pneumoperitoneum [23, 24, 25]. Different mechanisms are involved in the reduction of the urine amount during IAP. Shuto et al. showed that compression of the renal vessels and parenchyma with an insufflation pressure of 20 mmHg causes a significant decrease in renal blood flow(RBF) [26]. IAP also activates of the renin-angoitensin-aldosterone system following decreased renal perfusion, which results in renal cortical vasoconstriction. Nguyen et al [27] concluded that the level of ADH, renin, and aldosterone significantly increased during laparoscopic GBP. Chui et al [28] reported a decrease of 60% in renal cortical flow, which however returned to normal after desufflation. Otega et al [29] reported a precipitous rise in ADH concentration during laparoscopic cholecystectomy, which was not seen in open cholecystectomy. The exact mechanism of renal blood flow disturbance by pneumoperitoneum is still to be concluded, although volume status may play a major role. Renal blood flow has been measured during increasing IAP, and a gradual decrease in RBF up to 75% was observed upon reaching a pressure of 15 mmHg [30]. London et al [31] measured the RBF in pigs using a renal artery flow probe during IAP of 15 mmHg. Pigs were given maintenance fluids, bolus fluids, or hypertonic saline. A 30% drop in RBF was found in those with maintenance fluid, whereas this change was not noticed in well-hydrated animals with adequate volume loading. Controversially, there are also studies that reported no RBF changes during pneumoperitoneum. Yavuz et al [32] compared IAP of more that 15 mmHg and less that 10 mmHg using color microspheres to measure perfusions in pigs. A decrease was found in splenic, pancreatic, gastric mucosal blood flow, but the RBF was preserved in both high and low pressure groups. Ali et al [33], with an IAP of 15 mmHg, using ethyl nitrate and without on pigs found out that neither groups had a decreased RBF compared with the baseline. The serum creatinine levels have also been seen to rise during pneumoperitoneum. Krisch et al [34] using an IAP of 5 or 10 mmHg, reported a significant increase of serum creatinine in rats within the 10-mmHg group. The creatinine level however returned to baseline level after 2 hours following desufflation. Nguyen et al [23] found in their studies that urine output was decreased during IAP but found no significant changes in postoperative creatinine levels. Miki et al [35] compared IAP and wall lifting technique during cholecystectomy laparoscopy. They reported a decrease in urine output and GFR, with effective renal plasma flow, during laparoscopy but these changes were not seen with the abdominal wall lift device technique.

Splanchnic changes

The splanchnic circulation is also affected during raised IAP. Depending on intra-abdominal pressures, studies in animals have show decrease in splanchnic macro and micro-circulation [36, 37]. Signs of hepatocytic damage [38] were noticed, with increase of glutamic oxaloacetic transaminase and glutamic pyruvic transaminase. Impaired Kupffer cell function [39] and gastric intramucosal pH drop were also noticed [40]. One study in human looking at splanchnic circulation changes during IAP increasing form 10 to 15 mmHg showed reduction in blood flow of 40–54% in stomach, 32% in jejunum, 44% in colon, 39% in liver, and 60 % in peritoneum [41].

Complications

Anesthetists should always bear in mind the possible pulmonary complications of pneumoperitoneum like gas embolism, barotraumas, hypoxemia, pulmonary edema, atelectasis, subcutaneous emphysema, pneumothorax, pneumomediastinum and pneumopericardium. Carbon dioxide embolism is rare, occurring in about 0.0014–0.6% of laparoscopic surgeries [42, 43, 44], but with a mortality rate of about 28% [45]. Carbon dioxide enters the circulation through an opening in a damaged vessel under raised IAP. It can also occur if the Veress needle is misplaced into a vessel or parenchymal organ. Transesophagal echocardiography studies have shown bubbling of CO_2 in the right heart chamber in 68% asymptomatic patients during pneumoperitoneum [46]. Clinical manifestations of gas embolism are severe drop in blood pressure, cyanosis, cardiac arrhythmias or asystole. A mill-wheel murmur may be heard on auscultation of the heart, and $ETCO_2$ will increase.

Subcutaneous emphysema occurs in 0.3–3.0% laparoscopic surgeries [42, 46, 47]. Mild to severe subcutaneous emphysema has generally not been shown to have clinical effects, but upper airway obstruction must be considered if there is neck involvement. Pneumothorax can occur following peritoneum visceral tear, parietal pleura tear during resection around the esophagus or congenital defect in the diaphragm through which CO_2 gas travels [48, 49, 50]. Extension of emphysema can also occur, causing pneumothorax and pneumomediastinum. It has been reported that even subcutaneous emphysema arising from extraperitoneal inguinal hernia repair has extended to cause pneumothorax and pneumomediastinum [51, 52, 53, 54]. Pneumothorax should be differentiated with capnothorax following CO_2 diffusion into the intrapleural space. With both pneumothorax and capnothorax, the $ETCO_2$ increases, so capnothorax can be suspected if the mean airway pressure increases with a drop in SpO_2, and confirmation should be made with a chest x-ray. Pneumopericardium can develop when CO_2 is forced into the mediastinum and pericardium [55]. It can also occur if CO_2 enters the defect in the membranous portion of the diaphragm, resulting in a communication between the pericardial and peritoneal cavities [56].

Cardiovascular complications such as hypertension, arrhythmias, hypotension and cardiac arrest have been reported with pneumoperitoneum. Hypertension seems to have a higher incidence at the beginning of insufflation when the blood volume in the splanchnic vasculature is reduced due to increased IAP, thereby increasing preload and arterial pressure [57, 58]. Arrhythmias occur in up to 14–27% of laparoscopies [45]. These must be differentiated from arrhythmias caused by release of catecholamine. Sinus tachycardia and ventricular extrasystoles are usually more benign, and dangerous ones like bradyarrhythmias (bradycardia, nodal rhythm, atrioventricular dissociation and asystole) are also seen. Bradyarrhythmias arise due to the vagal nerve mediated cardiovascular response following acute stretching of the peritoneum [45]. Hypotension, which occurs in up to 13% of laparoscopies, is

a potentially serious complication [59]. IAP of 20 mmHg or more results in compression of the inferior vena cava, reducing the venous return. Cardiac output is reduced, leading to hypotension. This complication is aggravated by high intrathoracic pressure. Cardiac arrest has been reported 2–20 per 100,000 laparoscopies performed [45]. Vasovagal responses to quick intraperitoneal CO_2 insufflation and gas embolism have both been related to cardiac arrest.

The possible development of acute tubular necrosis in response to long lasting hypoperfusion from pneumoperitoneum is controversial. Koivusalo et al [60] compared 2 groups of patients during laparoscopic cholecystectomy using pneumoperitoneum 12 to 13 mmHg with an abdominal wall lift device. Urine-N-acetyl-B-D-glucosamonidase (marker for proximal tubular cell damage) level was higher in the pneumoperitoneum group. However, Micali et al [61] studied 31 patients during laparoscopic surgery, and 28 patients with open surgery. No differences were found in the two group's urine-N-acetyl-B-D-glucosamonidase, concluding that in their study pneumoperitoneum had no role in renal tubular injury.

Free radicals are released by inflation and deflation of the peritoneum [62]. Oxygen and organic free radicals may contribute to ischemia reperfusion phenomena or chemical carcinogenesis. Still, the impact of production of free radicals is smaller than with open surgery injury [63, 64].

Roles of patient positioning

Usually patients are put in Trendelenburg or reverse Trendelenburg position to facilitate the surgeon's view, and these positions have clinical impact. Joris et al [65] positioned patients on reverse Tredelenburg position for laparoscopic cholecystectomy. A reduced mean arterial pressure by 17% and cardiac index by 14% was noticed to patients on horizontal position. Gynecologic laparoscopic procedures are done in the Trendelendurg position. This tends to cause an increase in cardiac output with an increase in central venous pressure compared to horizontal position. This may help counteract the effects of insufflation [66]. Raised intracranial pressure and also intraocular pressure may be found in long procedures. Venous stagnation may lead to cyanosis and facial edema. Cephalad movement of the carina, which can lead to bronchial intubation, is also related to Trendelenburg position [67].

Other positions may be used as well. During lithotomy position, preload of the heart is increased, while pneumoperitoneum further increases the venous return. Patient's circulatory filling status plays a major role in the cardiac output. Right lateral decubitus position can cause compression of the inferior vena cava, resulting in hypotension.

Approach to general anesthesia, and management

Absolute contraindications to laparoscopy and pneumoperitoneum are rare. Nonetheless, pneumoperitoneum in patients with increased intracranial pressure or with significant hypovolemia is undesirable. Laparoscopy can be performed safely in patients with ventricular peritoneal shunt and peritoneojugular shunt if the shunts have a unidirectional valve resistant to the IAPs used during pneumoperitoneum. Anesthetic preparation is of utmost importance to face any of the possible complications that may occur during the procedure. Non-invasive blood pressure monitoring, electrocardiogram, pulse oximeter, $ETCO_2$ concentration monitoring, airway pressure monitoring and body temperature are used routinely. In patients with poor cardiopulmonary function or hemodynamic instability, invasive blood pressure monitoring should be used as well as blood gas analysis and urine output measurement. In patients with serious cardiac diseases, intraoperative assessment of cardiac function should be considered.

General anesthesia techniques for laparoscopy have been achieved using inhalation agents, intravenous agents and muscle relaxant. Among inhalation agents nitrous oxide, isoflurane, desflurane and sevoflurane have been widely used. Although nitrous oxide has repeatedly been linked to post operative nausea and vomiting(PONV), the actual contribution of N_2O to PONV is probably less than previously considered [68]. Intravenous induction agents such as propofol, thiopentone, etomidate, and muscle relaxants such as succinylcholine, mivacuronium, atracurium and vecuronium have all been reported to be used. Propofol among these has the advantage of less occurrence of PONV with ambulatory procedures [69], and etomidate with more PONV. Succinylcholine has been associated to muscular pain postoperatively, although after laparoscopy, pain may not be distinguishable when vecuronium. is used; nondepolarizing neuromuscular blocking drugs are usually preferred. Opioid supplementation namely, fentanyl, remifentanyl, alfentanyl and sufentanyl are commonly being used. Remifentanyl, which is rapidly hydrolysed by circulating and tissue nonspecific esterases, provides better control of hemodynamic responses compared with alfentanyl [70] and may therefore be preferable for infusions.

General anesthesia with tracheal intubation is certainly the safest technique recommended for patients with long laparoscopic intervention. The laryngeal mask (LMA) airway results in fewer cases of sore throat and may be used instead of endotracheal intubation [71, 72]. However, LMA does give any protection from aspiration of gastric contents in the airway [73, 74]. The ProSeal laryngeal mask airway may be an alternative to guarantee an airway seal up to 30 cm H_2O [75].

Settings of the IAP also should be monitored by the anesthesiologist during anesthesia. Recent studies recommend a moderate to low IAP of <12 mmHg to limit changes in splanchic perfusion, and resulting organ dysfunction will be minimal, transient and will not influence the outcome [76]. Using an IAP of 12mmHg or less is considered as the best approach to laparoscopic surgeries for safety considerations.

To enhance proper elimination of CO_2, and avoid hypercapnia and acidosis, ventilatory patterns must be adjusted. In order to maintain a eucapneic state in healthy patients, the ventilation minute volume should be increased by 15–25%. Use of positive end respiratory pressure (PEEP) also improves the gas exchange in the lungs [77], and maintains proper arterial oxygenation during long procedures [78]. However, PEEP combined with raised abdominal pressure, increases the intrathoracic pressure, thus reducing the cardiac output. Therefore, the use of PEEP should be used very cautiously in such circumstances [79, 80, 81, 82] and avoided in patients with cardiac dysfunction, or if hemodynamically unstable. The alveolar recruitment strategy has been proved to be efficient in improving arterial oxygenation during laparoscopic operations without any clinically adverse effect on cardio-respiratory system [83]. One version of this technique consists of manual ventilation with an airway pressure up to 40 cm H_2O for 10 breaths over 1 minute, shifting to mechanical ventilation with mild PEEP.

Among the pulmonary complications of pneumoperitoneum, gas embolism may be the most feared and dangerous complication. This complication develops principally during the induction of pneumoperitoneum, particularly in patients with previous abdominal surgery. For prevention of such complication the Veress needle should be inserted with the tap open and without connection to

the insufflation machine. If the needle has been unintentionally introduced into a large vein, blood would be seen escaping via the open end. Volume preload diminishes the risk of gas embolism and of paradoxical embolism. Suspicion of gas embolism should be quickly managed with the following steps [84, 85, 86]:

- The surgeon should be asked to deflate the pneumoperitoneum
- Position the patient in the left lateral position with head down, which allows the gas embolus to accumulate in the right ventricular apex, thus preventing it reaching the pulmonary artery or impeding blood flow through the heart.
- Rapid elimination of CO2 by increasing the minute ventilation and administer high flows of 100% oxygen.
- Cardiopulmonary resuscitation must be performed in case of asystole, and insertion of a central venous catheter may be considered to aspirate the gas, although this may not be timely
- Hyperbaric oxygen therapy can be used if available.

Pneumothorax requires treatment if there is cardiopulmonary compromise. If minimal compromise, treatment can be conservative, but if there is moderate to severe compromise, severe pneumothorax needs placement of a chest drain. In patients with chronic obstructive pulmonary disease (COPD) and in patients with a history of spontaneous pneumothorax or bullous emphysema, an increase in respiratory rate rather than tidal volume is preferable to avoid increased alveolar inflation and thereby reduce the risk of pneumothorax [87]. Capnothorax is usually reabsorbed after desufflation, with rapid re-expansion of the lung [88, 89]. Pneumopericardium is also managed according to severity of cardiopulmonary changes. Usually deflation of the peritoneum is enough for the symptoms to subside.

Hypertension is well managed pharmacologically, to prevent further complications like hemorrhagic stroke, pulmonary edema and cardiac depression. If pharmacological interventions remain ineffective, deflation of the peritoneum is advised till cardiac status is stabilized. Persisting symptoms may require conversion to open surgery.

Hemodynamic changes can also be reduced during beginning of insufflation by placing the patient in horizontal position rather than head up or head down [90]. Preoperative intravascular volume loading of 10–12 mL/kg helps to reduce the drop in cardiac output related to raise IAP. Intermittent pneumatic compression of the legs also increases venous return and cardiac preload [91] Reducing the IAP, increasing the minute ventilation and administering 100% oxygen terminate almost all of the arrhythmias [59, 92]. Anticholinergic drugs such as atropine and glycopyrrolate can be used accordingly.

Volume loading helps to prevent renal complications and low dose dopamine 2µg/kg/min may prevent renal dysfunction in long standing pneumoperitoneum with increase IAP >15 mmHg [93]. Insufflation of warmed CO_2 gas has shown to increase urine output, possibly due to local renal vasodilation and may be beneficial in patients with borderline renal function [94]. Use of esmolol may minimize renal hypoperfusion during laparoscopy since it inhibits renin release and attenuate the pressor effects to pneumoperitoneum [95, 96].

Abdominal wall lift

Many pathophysiological changes have been seen to occur with CO2 pneumoperitoneum. To minimize these changes, an abdominal wall lift technique has been used [97, 98]. With this method, very low IAP of 1–4 mmHg can be employed with low volumes of CO2, from 2–6 litres [98]. Reduction in circulatory changes and CO2 absorption has been reported using abdominal wall lift [22,99].

Conclusion

Large numbers of laparoscopic surgeries are performed each year. There are several non-negligible pathophysiologic changes that occur during pneumoperitoneum, and the anesthesiologist must have a very sound knowledge and understanding to act quickly and accurately whenever required. It is obvious now that with excellent understanding of the factors causing alterations in physiology, many measures can be undertaken to prevent complications that sometimes can prove to be fatal. Much careful attention must be shown about the details of proper patient selection and use of appropriate surgical technique. Good communication between the surgeon and the anesthetist is also of great importance. Also, low intraabdominal pressures during laparoscopic surgery should be encouraged to minimize the potential for numerous complications. The use of the abdominal wall lift technique should be encouraged. Thereby, the incidence of pathophysiologic changes associated with the use of CO_2 for pneumoperitneum may be reduced to a great extent.

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