SPECIALTY UPDATE

Do you have an infection problem?

In England and Wales, more than 175 000 hip and knee arthroplasties were performed in 2012. A steady increase in the demand for total knee arthroplasty (TKA) and total hip arthroplasty (THA) continues as a result of the ageing population and outstanding long-term results. These improved results can be attributed to technological advancements in prosthetic design, instrumentation and surgical technique, and joint arthroplasty surgery has proved to be the most cost effective procedure for patients with end-stage joint disease.

Prosthetic joint infection (PJI) following hip and knee arthroplasty is reported to range between 0.5% and 7% although in one series, 19% of TKAs were revised for infection and the overall incidence of infection after revision TKA was 9.2%. Infection still remains one of the major complications leading to loss of function and the need for revision surgery, which has a mortality of 2.7% to 18%. Patients with PJI have increased morbidity, requiring extensive medical and surgical treatment and posing a significant financial burden to hospitals. The United States infection following TKA, the average annual cost of $116,383 (44,416 to 269,914) compared with $28,249 (20,454 to 47,957) following uncomplicated surgery.

Kurtz et al projected that the volume of TKA will increase by 673% by 2030. Population demographics with an ageing population and increased comorbidities will increase the risk of PJI. Hence, any increase in the number of infected joints from a baseline infection rate of 1% would have a significant impact on healthcare provision in the National Health Service (NHS).

The importance of this problem has attracted research into factors that predispose patients into developing PJI. Berbari et al found that the risk of infection was increased by patient comorbidities such as a prior superficial surgical site infection (SSI), a National Nosocomial Infection Surveillance Score of 1 or 2 (Table I), the presence of malignancy and previous joint arthroplasty. Other risk factors thought to have a role include inflammatory arthropathies, immunosuppression, diabetes, renal failure, heart or lung disease, smoking, obesity, prolonged post-operative wound drainage and haematoma formation.

Modern advancements in anaesthetic and surgical practice, prosthetic design, ultra-clean airflow, prophylactic antibiotics, improved pre-assessment and better post-operative care have all helped to reduce infection rates. However, there is still a significant risk of around 1% infection.

Berbari et al demonstrated in a matched case control study that over 22 years 1.8% of...
people will develop a PJI. When counselling patients for surgery, the risk of infection may be inaccurate if patient risk factors are not considered. Ideally surgeons should be able to stratify patients for risk before surgery and provide a more accurate estimation of the risk of infection, as this would influence the patient’s choices whether to proceed with the operation. Risk stratification may also have implications when deciding which antibiotic regimens to follow both pre- and post-operatively. It would be useful to list patient risk factors and in turn calculate their risk of developing a PJI, but insufficient accurate information is currently available to give firm advice. Parvizi et al\(^\text{13}\) have refined the definition for PJI (Table II)\(^\text{13}\) and Public Health England (PHE) have clarified the definition of an infected wound, which is now widely used in the SSI surveillance service (SSISS).\(^\text{14}\) However, currently used definitions for SSIs have been shown to be unreliable because of poor inter-observer reliability.\(^\text{15}\) Ashby et al\(^\text{16}\) highlighted the need for a single, accurate and reproducible definition of SSI in order to allow its use as a reliable performance indicator.

The potential size, expense and complexity of managing the workload of PJI may be so great that development of specialist ‘infection centres’ would be warranted to maximise efficiency and delivery of treatment regimens and expertise. Recently there has been increased attention drawn to outcomes as part of clinical governance and quality assurance programmes.\(^\text{21}\) Hospital league tables and surgeon’s outcome data have also entered the general public domain but may be misleading in the absence of detailed analysis of case mix. Calculating infection rates to be used as comparisons for different hospitals is difficult unless patient risk factors and local demographic details are considered. It has already been highlighted that oversimplifying the calculation and comparison of surgeon specific wound infection rates can lead to misinterpretation.\(^\text{22}\) Failure to adjust the expected outcome for surgeons with an extensive revision or complex high-risk arthroplasty practice is unfairly judging the performance of these surgeons. Comparing infection rates for surgeons in these circumstances could harm the professional relationship with the patient if patient’s perception was that post-operative joint infection was a surgeon-related issue rather than allied to the patient’s comorbidity.

**Detection of infection**

The Department of Health and the Health Protection Agency established a national surveillance programme in 1997 SSISS to help NHS Trusts monitor SSI.\(^\text{14}\) At its inception data submission was obligatory only for one-quarter in a year but it was apparent that this would not represent a true overall picture and that continuous surveillance would be required. In recent years the reduction in post-operative length of stay may have led to a number of SSIs being

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**Table I. The National Nosocomial Infection Surveillance Risk Index**

In 1991, the Centers for Disease Control (CDC) developed the National Nosocomial Infections System risk index which ranges from 0 to 3 points and is defined by three independent and equally weighted variables. One point is scored for each of the following when present:

- American Society of Anaesthesiologists (ASA) physical status classification > 2
- Either contaminated or dirty/infected wound classification
- Length of operation > T hours (where T is approximate 75th percentile of duration of the specific operation being performed, 90 minutes in hip and knee arthroplasty)

**Table II. Defining periprosthetic joint infection (PJI), Parvizi et al\(^\text{13}\)**

Based on the proposed criteria, a definite diagnosis of PJI can be made when the following conditions are met:

- A sinus tract communicating with the prosthesis; or
- A pathogen is isolated by culture from two separate tissue or fluid samples obtained from the affected prosthetic joint; or
- Four of the following six criteria exist:
  - Elevated serum erythrocyte sedimentation rate (erythrocyte sedimentation rate \(> 30\) mm/h), or serum C-reactive protein concentration (C-reactive protein \(> 10\) mg/dl)\(^\text{17,18}\)
  - Elevated synovial white blood cell count (WCC) (WCC \(> 1100\) cells/\(\mu\)L in chronic cases,\(^\text{17}\) WCC \(> 27\) 800 cells/\(\mu\)L in acute cases)\(^\text{19}\)
  - Elevated synovial neutrophil percentage (PMN > 64%)\(^\text{20}\)
  - Presence of purulence in the affected joint
  - Isolation of a microorganism in one culture of periprosthetic tissue or fluid
  - Greater than five neutrophils per high-power field in five high-power fields observed from histologic analysis of periprosthetic tissue at 400-times magnification

However, it should be noted that PJI may be present even if fewer than four of these criteria are met\(^\text{13}\)
unidentified, as patients have been discharged before developing an infection. Previous studies have shown that 12% to 84% of SSIs are detected after a patient has been discharged from hospital.\textsuperscript{23-26} To address this concern SSISs have developed post-discharge surveillance (PDS)\textsuperscript{14} using either outpatient clinic review or direct patient contact via questionnaire in order to confirm the nature of the patients course after leaving hospital.

The study on the efficacy of nosocomial infection control showed that well organised surveillance and infection control programmes that included feedback of infection rates to surgeons were associated with significant reductions in SSI.\textsuperscript{27} Currently, NHS trusts receive a letter alerting them if they are an outlier in the data set which instigates an audit and root cause analysis of individual patients, with the aim of improving services in the future. However, only full engagement in this data collection will allow accurate observations of national trends in infection rates so that individual fluctuations may be fairly represented across the country.

Establishing benchmarks of SSIs and comparing the results for individual trusts enables outbreaks of infection and lapses in infection control to be addressed. A number of SSISs have demonstrated significant reductions in rates of SSI in hospitals that participate in these benchmarking schemes.\textsuperscript{28,29} One of the primary goals of the SSIS is to offer a standardised methodology to participating hospitals to enable them to assess their own infection rates enabling comparison with other institutions. SSIs are defined according to a standardised set of clinical criteria that affect the superficial tissues (skin and subcutaneous tissues) of the incision and those that affect the deeper tissues (deep incisional and organ space).\textsuperscript{30} This, together with the level of wound contamination and duration of surgery, constitute the three components of the National Healthcare Safety Network Risk Index.\textsuperscript{31} Information collected by hospitals also includes the American Society of Anesthesiologists (ASA)\textsuperscript{32} score, which helps to classify a patients’ pre-operative physical status. However, there is debate regarding the relevance of this assessment as a risk stratification tool in joint arthroplasty\textsuperscript{33} because all wounds would be deemed clean and all primary operations will probably take less than 90 minutes. In addition to this, the ASA score is not designed to quantify infection, an example being that both diabetes and hypertension have the same ASA score but present very different risks of PJI. It might reasonably be suggested that this deficiency requires some other system of risk stratification for orthopaedic surgery.

Of equal concern is the wide variation in SSI surveillance report rates. In the 2012/2013 report, three eligible NHS trusts did not participate in the surveillance process at all and continuous surveillance was only employed by 55% and 56% of centres for TKA and THA, respectively. The data derived from the SSISs are not satisfactory for high quality surveillance studies or research trials of interventions in SSI.\textsuperscript{34}

The quality of data has also been questioned with some hospitals having poor compliance with guidelines and reporting.\textsuperscript{35} Indeed data collection methods are highly variable between hospitals with some units not using PDS, relying on inpatient data alone. This could clearly result in an under-reporting of infection rates when length of stay is generally less than five days, compared with the infection rate with the inclusion of PDS at 30 days.

Definitions of infection and compliance have also been an issue with 30% of hospitals not submitting a complete set of data.\textsuperscript{14} Inter-hospital comparisons, which are an essential component of a national surveillance strategy, are of limited statistical validity without appropriate risk adjustment. It might be suggested that hospitals with high quality SSI surveillance could be reporting higher rates of infection because of close surveillance and follow-up and then be penalised resulting in work being commissioned at hospitals with seemingly lower SSI rates but with poor reporting compliance. Equally, without a balanced approach to the real risk stratification and the case mix, the data will be weak.

**Exeter experience**

In Exeter, continuous surveillance has been undertaken since 2008 for spinal surgery, THA and TKA. The Orthopaedic department has fully supported the infection prevention control team in this surveillance, providing assistance with data from pre-operative preparation, the operating theatre and the ward. Initially the SSIS focused on inpatient stay but PDS was introduced and led by an infection control nurse in 2008 which has enabled accurate data to be collated in a cost-effective and unbiased manner. Within our unit since 2010 a case-by-case review has been performed for all PJIs.

We have recorded the history of the entire episode including: the date of onset of symptoms, the number of days after the operation, type of SSI, comorbidities, body mass index (BMI) and type of micro-organism involved. An individual root cause analysis was performed for each patient to see if there were any shared associations or causative events which if addressed would have reduced the chance of SSI. This process led to a thorough review and rationalisation of theatre practice at the end of 2011. After close liaison between the surgical teams and infection control, departmental policy was developed regarding the use of pre-operative antibiotics and drains, wound care on the ward and management of any persistently leaking wounds. It was also noted that in some situations there had been a mixing of emergency medical patients with post-operative joint arthroplasty patients on the ward and as a result the ring fencing of elective patients was re-established.

Theatre practice review highlighted key issues that may have affected equipment sterility, such as knee sets being wrapped in drapes rather than metal containers. The pre-operative laying up of instruments and trial components was also reviewed and the amount of time before the operation was analysed, as well as the positioning of trolleys and their vicinity to the laminar flow. Attention was
paid to skin preparation and wound draping. We analysed the use of high protection gowns, air warming blankets, tranexamic acid, thromboprophylaxis, local anaesthetic infiltration, knee system changes and early mobilisation regimens, as well as the wound dressing policies to ensure optimal management of the surgical incision. Post-operative antibiotic regimens were reviewed with particular attention to clinicians’ adherence to microbiology advice, prescribing accuracy and the patients’ compliance.

In Exeter, there is a close working relationship with the microbiology department and infection control team. As a result of continuing detailed analysis between 2010 and 2013 our infection rate in TKA was 0.8%, with the last five quarters having a zero rate for PJI. This has confirmed that the National Joint Registry and Royal College of Surgeons dashboard data are accurate and that Exeter has one of the lowest rates in the United Kingdom.

Compliance
In the most recent report on SSI in orthopaedic surgery published by the Health Protection Agency, 183 NHS hospitals and nine NHS treatment centres participated in the 2012/13 survey, contributing data on 96 408 procedures. Hospital participation in the mandatory orthopaedic scheme decreased slightly in 2012/13 from 186 in the previous year. The reported surgical volume has increased 290% between April 2004 and March 2013. Three eligible NHS Trusts did not contribute orthopaedic data during this period. The proportion of hospitals undertaking continuous surveillance continued to increase in 2012/13 but it is still only 55% for knee prostheses, and 56% for hip prostheses, which is still behind coronary artery bypass grafting (67%). Data completion was above 99% for patient age, gender, duration of operation, wound class, OPCS code and date of admission. BMI had the lowest data completion rate at 32%, despite the literature regarding BMI as one of the most important risk factors for complication rates. For hip and knee prostheses, the risk of SSI was highest for surgery undertaken for revision owing to a previous infection (6.0% and 2.8%, respectively), it was also noted that the incidence of inpatient infections has been in decline since 2004, probably because of the decreasing length of hospital stay (66% of SSIs were detected as re-admissions for TKA). Of 143 NHS trusts participating in the orthopaedic surveillance, 12% failed to fulfill the rather unambitious target of submitting data in one surgical category for one surveillance quarter. The previously identified upward trend in the rate of SSI for knee prosthesis was not sustained in 2012/13. The cumulative incidence of SSI based on the last five years’ data captured was lowest for knee prosthesis surgery at 0.6%. This is lower than would be expected from the literature and probably doesn’t reflect the true data set, if full submission and PDS had occurred. A total of nine NHS Trusts were identified as high outliers in 2012/13 with an incidence of SSI higher than that expected nationally and 13 NHS Trusts were identified as low outliers. As part of the PHE remit these trusts are informed of their data set and asked to undertake further investigations. Low outliers may reflect a high standard of infection control and surgical discipline, but they could equally be units missing cases of SSI with incomplete data capture and thus warrant review of their surveillance methodology.

In summary, we recommend that all arthroplasty surgeons should be aware of both local and national surveillance procedures, their own compliance with data submission and the quality and type of data that is being submitted. As surgeons, it is paramount to establish ownership of this information to help improve accuracy and drive up standards of care. It is also important that orthopaedic surgeons engage with the microbiology and infection control teams. Although many patient related risk factors are uncontrollable there are several factors in the peri-operative period that can be identified in order to minimise the risk of SSI to the patient. Parvizi, Gehrke and Chen have produced an international consensus on PJI to help answer some pertinent questions. The creation and implementation of frameworks and key standards will enable us to monitor and reduce infection rates, which is still one of the most devastating post-operative complications following total joint arthroplasty.

Supplementary material
Classifications of surgical site infections are available alongside the online version of this article at www.bjj.boneandjoint.org.uk

Author contributions:
A. Patel: Literature search, write up, corrections and review.
G. Pavlou: Writing of paper, revisions and corrections.
R. A. Ahmad: Review.
A. Toms: Project inception concept and write up.

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References