SHORT REPORT

Cost effective use of satellite packs in neonates: importance of birth weight
A Gupta, R Patel, M Dyke

Background: Blood banks split an adult packed red cell bag (usually 250 ml) into 30 ml bags, making a total of eight neonatal “satellite” packs per donor. These packs are then “allocated” or “committed” to be used to serially transfuse a newborn.

Aim: To study transfusion requirements of premature infants in relation to their birth weight and thereby attempt to rationalise the method of dispensing satellite blood packs.

Method: Data on the distribution of neonatal transfusions with respect to weight were obtained retrospectively from unit A (51 infants, 168 transfusions) and unit B (46 infants, 151 transfusions). These data were used to model the effect of different policies on donor exposure and number of unused packs.

Results: Infants weighing less than 1000 g at birth have significantly higher transfusion requirements than those weighing more than 1000 g or p = 0.001 (unit A), p = 0.004 (unit B)). Our model predicted a significant reduction in donor exposure if eight packs/infant were allocated to those weighing less than 1000 g, and a significant cut in the number of unused packs if four satellite packs/infant were allocated to those weighing more than 1000 g.

Conclusions: It would be safer and cost effective to allocate eight packs/infant to those with birth weights < 1000 g and four packs/infant to those with birth weights > 1000 g.

Low birthweight infants (defined here as birth weight < 1000 g) often require transfusion. Risks associated with transfusions range from mistake in identity (commonest cause of morbidity) and transmission of infection to rare events such as graft versus host disease. The risk of contracting HIV from blood transfusion is less than 1 in a million; however, the risk of contracting variant CJD is not known and is far less severely theoretical.

Over the past decade we have moved from using whole blood for neonatal top up transfusions to using multiple stored packed cells for serial transfusion. The use of satellite packs has been shown to be safe and reduces donor exposure significantly.

Endorsing this view, the Royal College of Paediatrics and Child Health (RCPCH) guidelines on neonatal blood transfusion have recommended that multiple satellite bags from a single donor should be used for serial transfusions to an infant. The guidelines, however, do not specify whether a whole adult bag or a specific number of satellite packs should be allocated to an infant. Allocating fewer than the required number may increase the risk of multiple donor exposure. Conversely, allocating too many will result in wastage of unused satellite packs. Low birthweight infants have higher transfusion requirements because of the need for more intensive care and higher sampling losses in relation to body weight than larger infants. Can this information be used to make allocation of satellite units more cost effective? None of the eight tertiary level neonatal units in London that we surveyed considered birth weight when allocating satellite packs.

We studied the distribution of transfusion requirements in relation to birth weight and examined a method of allocation that would minimise donor exposure and wastage of unused satellite packs.

METHODS

We retrospectively collected data from two neonatal units over a six month period. Unit A (51 infants and 168 transfusions, study period September 1999 to March 2000) was a tertiary level unit, and unit B (46 infants, 151 transfusions, study period February 2000 to August 2000) was a subregional centre. The distribution of the number of transfusions in relation to birth weight was studied. Infants were divided into two groups according to birth weight (< 1000 g) and number of transfusions given were compared. We excluded infants who had surgical conditions, died, or were transferred to another unit and those who had received recombinant erythropoietin.

The policies on the indications for transfusion differed slightly in the two units. Unit A and unit B both transfused oxygen dependent infants in order to maintain haemoglobin concentration above 130 and 120 g/l respectively. Both units transfused symptomatic (poor weight gain, tachypnoea) infants with haemoglobin concentration below 80 g/l. In asymptomatic infants, the concentration was allowed to fall to 60–80 g/l. The amount of blood transfused per transfusion was 10–20 ml/kg in both units. Unit A allocated eight packs to all infants, whereas unit B did not pre-allocate satellite packs.

We modelled the effect of different methods of allocation (universal allocation of four satellite packs/infant and eight satellite packs/infant, and a differential allocation of eight satellite packs for those weighing less than 1000 g and four satellite packs for those weighing more than 1000 g) on donor exposure and number of unused packs. We based the model on the data collected from units A and B. For the purposes of our model, we assumed that blood was allocated on day 1 of the shelf life of the satellite packs (taken to be 35 days). In practice, the age of the satellite packs may vary and may result in higher rates of donor exposure (across all groups) than predicted. We took into consideration the fact that not all transfusion requirements were met during the shelf life of the satellite pack.

RESULTS

Birth weight and transfusions

We analysed the data from 51 infants in unit A and 46 infants in unit B (table 1).

The birth weight and number of transfusions required are negatively correlated (Pearson’s coefficient –0.44, p < 0.001).
Cost effective use of satellite packs in neonates

Using a cut off (marked by arrow on fig 1) of 1000 g, we divided the infants into two groups and studied the distribution of the number of transfusions (table 2).

Infants weighing < 1000 g at birth had a significantly higher transfusion requirement (table 2).

Table 3 depicts a model created using data from units A and B, showing the effect of different allocation policies on donor exposure and number of unused packs.

**DISCUSSION**

We have confirmed that the number of transfusions required and birth weight are inversely related. Although the two units in this study offered different levels of care and differed with regard to the threshold used to transfuse infants, the difference in the transfusion requirements relating to birth weight was significant in both units. Our model (table 3) reflects these differences and predicts that a method of differential allocation of eight packs to infants of birth weight less than 1000 g* and four packs to those of birth weight 1000 g or above† would be most cost effective.

With improvements in neonatal care, transfusion requirements in newborns are falling. Widness et al\(^b\) showed that over a 12 year period (1982 to 1993), there was a progressive decline in red blood cell transfusions, donor exposure, and transfusion volumes occurring concurrently with decreases in mortality and morbidity. Most (70%) transfusions were given in the first 4 weeks of life (when infants are sickest). Importantly, although the percentage of infants of birth weight ≥ 1000 g and never receiving any transfusions increased with time (17% in 1982, 33% in 1989, and 64% in 1993), more than 95% of infants weighing 1000 g or less in all years received transfusions.

Blood transfusion requirements depend on several factors such as level of intensive care required,\(^c\) coexisting morbidity, gestation, age of the infant, and the blood bank policy on transfusions. Often 10–15% of the circulating blood volume in seriously ill neonates is removed for laboratory tests in the first 2 days of life.\(^d\) The major causes of anaemia in small infants are phlebotomy losses and a diminished ability to mount an effective erythropoietin response to the falling red cell mass.\(^d\)

Recent improvements in neonatal care have had a significant impact on reducing the number of blood transfusions required. However, the method of dispensing an adult packed cell unit could have significant implications in relation to donor exposure and costs (the material cost of one satellite bag is about £16).

Neonatal units differ considerably in the method of allocation of satellite packs. Centres practising neonatal care should develop their own protocols for transfusions\(^2\) by liaising with their local blood bank and arriving at a consensus on the dispensing of an adult packed cell unit. The number of satellite packs allocated may, however, need to reflect coexisting morbidity.

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Accepted 12 January 2003

**REFERENCES**


**Table 1** Characteristics of the two units studied

<table>
<thead>
<tr>
<th></th>
<th>Unit A</th>
<th>Unit B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of infants</td>
<td>51</td>
<td>46</td>
</tr>
<tr>
<td>Number of transfusions</td>
<td>168</td>
<td>151</td>
</tr>
<tr>
<td>Excluded from study</td>
<td>5 (3 deaths, 2 surgical cases)</td>
<td>10 (deaths, 3 had fatal surgical conditions)</td>
</tr>
</tbody>
</table>

**Table 2** Distribution of the number of transfusions by birth weight

<table>
<thead>
<tr>
<th>Birth weight (g)</th>
<th>Unit A</th>
<th>Unit B</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1000 g</td>
<td>9</td>
<td>37</td>
</tr>
<tr>
<td>≥1000 g</td>
<td>16</td>
<td>20</td>
</tr>
</tbody>
</table>

**Table 3** Model showing the effect of different allocation policies on donor exposure and number of unused packs

<table>
<thead>
<tr>
<th>Donors/infant ([&lt;1000 g]</th>
<th>2.28 (1.3)</th>
<th>1.31 (0.69)*</th>
<th>0.98 (CI 0.52 to 1.5); p&lt;0.0001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donors/infant (≥1000 g)</td>
<td>1.06 (0.3)</td>
<td>1.02 (0.14)</td>
<td>p = 0.413</td>
</tr>
<tr>
<td>Unused packs/infant (&lt;1000 g)</td>
<td>1.43 (1.13)</td>
<td>4.27 (2.6)</td>
<td>2.8 (CI 1.8 to 3.8); p&lt;0.001</td>
</tr>
<tr>
<td>Unused packs/infant (≥1000 g)</td>
<td>2.15 (0.85)</td>
<td>6.0 (1.15)</td>
<td>3.86 (CI 3.4 to 4.2); p&lt;0.0001</td>
</tr>
</tbody>
</table>

Values are mean (SD) unless otherwise indicated.

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*See the Discussion.*
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Arch Dis Child Fetal Neonatal Ed 2004 89: F182-F183
doi: 10.1136/adc.2002.021147

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Neonatologists are not always directly involved in the intensive care of neonates as surgical patients. In my own case this has led to a slightly blinkered approach. I am very familiar with perinatal stabilisation of problems such as hydrops, extreme prematurity, patent ductus arteriosus, and the intensive care of infants with diaphragmatic hernias, and with the referral of infants with less acute problems. However, perioperative management, particularly of uncomplicated cases, and the mysteries of operative techniques have been beyond my reach. A book, with neonatologists within its scope, ideally with strong emphasis on presentation, embryology, and associations as well as description of surgical techniques, would plug a significant gap in my knowledge.

With 97 chapters, typically under 10 pages each, this book certainly has breadth of coverage. Chapters typically deal with a problem such as chylothorax, subclavian stenosis, or necrotising enterocolitis and describe the authors’ perspective on management. There are numerous photographs, radiographs, and drawings in nice balance within each chapter. The book is divided into sections to complement the “comprehensive description of operative techniques” left me wondering that such complicated operations could be so well described. The authors are drawn from all over the world, but the book’s style remains uniformly European.

The book begins with a series of chapters dedicated to general and theoretical aspects of the care of these high risk infants. These areas of overlap with standard neonatal texts are very variable and, from my perspective, also very interesting. Some could have been more up to date. It was also interesting for example to see a chapter on neonatal transport written by two paediatric surgeons rather than by neonatologists.

Some overlap is inevitable in a book like this. However, I would have preferred, for example, for there to be more embryology in each surgical chapter or a more comprehensive introductory chapter. A well written chapter on ethics, from a purely North American perspective, occupies eight pages, which is also the space given to parenteral nutrition. The five sides dedicated to respiratory management of the newborn emphasised to me the potential rewards to be reaped from closer integration of training and practice in neonatology and newborn surgery. The chapters on surgical problems are the book’s strongest area. We have found the book valuable in furthering our understanding of the problems we see on a day to day basis. Many of the lesions in question are relatively rare, which makes the superspecialist multiauthour approach most valuable. The inclusion of problems sometimes dealt with by neurosurgeons and plastic surgery specialists made this an especially attractive volume. Only the occasional chapter seemed to focus too heavily on the authors’ own experience without consideration for the variety of techniques in use.

I am glad to say that this book is the one to plug the gaps in my knowledge. I would therefore recommend this book to fellow paediatricians, much as I would encourage surgeons and neonatologists to further develop collaboration in practice and in training.

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Dehydration: the main cause of fever during the first week of life

We read with interest the findings of Maayan-Metzger et al on fever in healthy newborns during the first days of life.7 It is difficult to identify febrile neonates at low risk of serious bacterial infection.7 Although no consensus exists on the optimal approach to diagnosis and treatment, current guidelines recommend that febrile infants less than 28 days of age be admitted to hospital and given intravenous antibiotics for 48-72 hours. However, as mentioned in this report, dehydration is the primary cause of fever especially during the first days of life. We retrospectively reviewed the medical charts of patients admitted to our neonatal intensive care unit with fever between 1 May 1999 and 30 September 2003.

The inclusion criteria were gestational age >37 weeks, 1–7 days of postnatal age excluding the first day of life, axillary or rectal temperature >37.8 °C on admission, and normal physical examination with well appearance, no signs of focal infection, and no history of illness or antibiotics.

Overall, 46 febrile neonates were included in the study. Most (90–95%) were exclusively breast fed. Laboratory data included complete blood count, C reactive protein, serum urea and sodium concentrations, urinalysis, and blood, urine, and cerebrospinal fluid cultures. The mean (SD) duration of fever was 3.4 (1.9) days. The mean (SD) of 2.8 (2.4) hours. Twenty seven infants (59%) had lost 8–24% of their birth weights. In 34 of the babies, white blood cell counts were between 5000 and 15 000/mm3. Serum sodium concentrations were obtained in 35 patients: mean (SD) was 147 (6.7) mmol/l, and in 14 (40%) the levels were equal to or higher than 150 mmol/l. There was a positive correlation between weight loss and high serum sodium concentration (p = 0.002). Mean (SD) serum urea nitrogen concentration was 19.3 (11.1) mmol/l. In 22 (48%) babies, serum bilirubin concentration was equal to or greater than 220 μmol/l.

Cultures were positive in seven babies. Coagulase negative staphylococci were recovered from five blood cultures and considered...
to be contaminated both clinically and in a negative repeated culture. In one infant, blood culture was positive for Staphylococcus aurous, and Entenococcus grew from culture of the urine in the other. Most admissions (83%) were between June and early October, which are the warmest months of the year in this area. In this low risk group of infants, only two patients had serious bacterial infection. Comparable with the findings of Maayan-Metzger et al., the results of our study support dehydration as the main cause of fever during the first week of life. As most of our cases occurred during summer and early autumn, environmental temperature may have an additive effect in this population.

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doi: 10.1136/adc.2003.047696

References

Increasing incidence of moderate neonatal hyperbilirubinaemia in Wirral
Severe neonatal jaundice and bilirubin encephalopathy have been reported with increasing frequency from North America and Europe.1-3 There are no published reports of similar trends in Britain. We therefore examined trends in moderate neonatal hyperbilirubinaemia in Wirral Hospital between 1991 and 2001. Neonates of >34 weeks gestation with a serum bilirubin of >340 µmol/l were identified from the laboratory database. Trends in hyperbilirubinaemia were analysed using the χ2 test for trend. A total of 184 infants were identified; 122 presented before initial discharge, and 62 were readmitted. Median (interquartile range) gestational age was 38 (37–39) weeks, and 69% of affected infants were breast fed. The incidence of moderate jaundice increased from 2.4/1000 live births in 1991 to 5.5/1000 in 2001 (p < 0.0001). Despite a progressive fall in annual births, readmissions for jaundice increased from seven in the first six years of study to 55 in the second five years (p < 0.0001). Five infants needed exchange transfusion; all had haemolytic diseases. All were identified before initial discharge. No infants developed bilirubin encephalopathy, and none died.

Ours is the only report of recent trends in neonatal jaundice in Britain. Whether our experience is representative is not known, nor is the national incidence of bilirubin encephalopathy. These questions may be answered by this continuing study, supported by the British Paediatric Surveillance Unit, of severe neonatal jaundice.

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Use of abbreviations in daily progress notes
Errors in medication and documentation are reported.1-4 These errors, no matter how minor, could have grave consequences for the patient, especially in the paediatric population. We have analysed trends in moderate jaundice in our neonatal intensive care unit. Being the busiest centre in the country, managing the great majority of seriously sick neonates, we are at a very high risk of these errors. In view of this and as a screening audit, we looked at a few progress notes written on our inpatient neonates. One example of a progress note, written by a junior doctor, stated: “Prem 32 WOG, F & G: Problems: RDS, IVH II, S/P SVT, Stable on RA, TPR normal, PU, BO, Chest, CVS & abdomen: NAD”. This excessive and inappropriate use of abbreviations is alarming and disturbing. The abbreviations used denoted the following (in order of citation): weeks of gestation, feeder and grow, respiratory distress syndrome, intraventricular grade 2 haemorrhage, status supraventricular tachycardia, room air, temperature pulse respiration, passed urine, bowel open, cardiovascular system, and no abnormality detected. This prompted us to look further into the inadequate use of abbreviations in the daily progress notes in our neonatal unit.

A cross section survey was carried out at the Special Care Baby Unit (SCBU), Royal Hospital, Muscat, on 7 October 2003. Thirty consecutive charts were reviewed. The progress notes written by seven different doctors (three registrars and four resident medical officers) were analysed for use of abbreviations. The commonly used ones were: CP (crystalline penicillin), RR (respiratory rate), HR (heart rate), BP (blood pressure), PA (per abdomen), O/E (on examination), NGT (nasogastric tube), UEI (urea and electrolyte I), BGA (blood gas analysis), BBA (born before arrival), TPN (total parental nutrition), SLS (standard lipid solution), STS (standard TPN solution), D/w (discussed with), SBR (serum bilirubin), CTG (cardio- tocograph), IUGR (intrauterine growth restriction), IVT (Blalock-Taussig shunt), TAT (trans-anastomotic tube), IVF (intravenous fluid or in vitro fertilisation), POD (postoperative day), ASD (atrial septal defect), VSD (ventricular septal defect), PDA (patent ductus arteriosus), TR (tricuspid regurgitation), L-R shunt (left to right shunt), TOF (tetrology of Fallot), CRT (capillary refill time). One interesting note that started ABs after ABC” (ABs, antibiotics; ABC, abdomen). One interesting note that stood out was “Plan is to start ARBs after ABC” (ABs, antibiotics; ABC, aerobic blood culture).

We noted a high frequency of the use of abbreviations in our neonatal unit. This was a single day observation; we would expect much more variation in our clinical study. Fortunately, none of the abbreviations had resulted in erroneous interpretation, as most of the staff were used to them. However, this does not indicate that it is all right to use abbreviations. Standard abbreviations, such as VSD (ventricular septal defect) and PDA (patent ductus arteriosus), are acceptable, whereas others are not.

Documentation errors have been reported to be an increasing problem in day to day care of patients.1-4 A recent report described the same negligence in documentation by residents. Carroll et al1 found discrepancies in the daily progress notes written by a resident doctor in the neonatal intensive care unit. They also found that notes often contained inaccurate information and lacked pertinent information. We looked further into the situation and found extensive use of abbreviations in progress notes.

Our observation is not unique and requires rectification. The solution could be to standardise or eliminate the use of abbreviations in the unit. Total elimination would be difficult, as many of the abbreviations are acceptable. Thus, the use of unacceptable abbreviations should be discouraged. Neonatal medical officers should be given brief instruction on the writing of appropriate progress notes. An alternative is to use the electronic information system for all medical transcription including progress notes, as described elsewhere.1,5

In conclusion, care of neonates requires good documentation of day to day progress. The use of unacceptable abbreviations should be discouraged. A follow up audit is warranted to look further into the effect and success of our recommendations.

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doi: 10.1136/adc.2003.045591

References

Use of nasal continuous positive airway pressure during neonatal transfer
Within neonatal intensive care units, nasal continuous positive airway pressure (nCPAP)
What is the normal range of blood glucose concentration in healthy term newborns? The report by Dr Nicholl on “normal blood glucose concentrations in healthy term newborns” raises the interesting and important question of how normoglycaemia in newborns can be defined. In a comprehensive review of the literature in 1997, an expert panel of the World Health Organization concluded that there are numerous approaches to defining normoglycaemia, including the statistical approach (which was taken by Dr Nicholl), the metabolic approach (what is the concentration of blood glucose at which normal cell homoeostasis is maintained?), the neurophysiological approach (below what concentration of blood glucose does impairment of neurological functions occur?), and, perhaps most importantly, the neurodevelopmental approach (does a relation exist between neonatal blood glucose concentrations and the neurodevelopmental outcome of children years later?). These different approaches towards definition of normoglycaemia contribute to the controversy that surrounds this issue. Other factors that influence newborn blood glucose concentrations, even in healthy term newborns, are perinatal complications, mode of delivery, and feeding behaviour. It appears therefore that there is very little solid evidence on which judgment of neonatal blood glucose concentrations can be based. Follow up studies looking at neurodevelopmental outcome of neonatal “hypoglycaemia” (and its treatment) in healthy term infants of various delivery modes and birth weights are urgently needed.

What is the normal range of blood glucose concentration in healthy term newborns?

The report by Dr Nicholl on “normal blood glucose concentrations in healthy term newborns” raises the interesting and important question of how normoglycaemia in newborns can be defined. In a comprehensive review of the literature in 1997, an expert panel of the World Health Organization concluded that there are numerous approaches to defining normoglycaemia, including the statistical approach (which was taken by Dr Nicholl), the metabolic approach (what is the concentration of blood glucose at which normal cell homoeostasis is maintained?), the neurophysiological approach (below what concentration of blood glucose does impairment of neurological functions occur?), and, perhaps most importantly, the neurodevelopmental approach (does a relation exist between neonatal blood glucose concentrations and the neurodevelopmental outcome of children years later?). These different approaches towards definition of normoglycaemia contribute to the controversy that surrounds this issue. Other factors that influence newborn blood glucose concentrations, even in healthy term newborns, are perinatal complications, mode of delivery, and feeding behaviour. It appears therefore that there is very little solid evidence on which judgment of neonatal blood glucose concentrations can be based. Follow up studies looking at neurodevelopmental outcome of neonatal “hypoglycaemia” (and its treatment) in healthy term infants of various delivery modes and birth weights are urgently needed.

References

1 Nicholl OR. What is the normal range of blood glucose concentrations in healthy term newborns? Arch Dis Child 2003;88:238–9.

Gastric perforation and transillumination

We read with interest the article of Farrugia and colleagues’ about neonatal gastrointestinal perforation. However, there was no mention of:

- Isolated gastric perforation as a cause of neonatal gut perforation, or
- Transillumination as a simple diagnostic tool of pneumoperitoneum.

We highlight these two points relating to a recent case. A 29 week gestation baby girl was born by vaginal delivery. She initially required conventional ventilation for her lung disease. An umbilical arterial catheter was inserted but removed after a few hours due to sluggishness of the toes. On day 2 she was evaluated and nCPAP was tried. After a few hours, her condition deteriorated and she returned to conventional ventilation. On day 4, she was started on enteral feeding, using small volumes of breast milk, but had mild abdominal distension and some aspirates. Feeding was stopped. Her abdomen deteriorated and she had persistent metabolic acidosis. Transillumination of her abdomen was positive (fig 1) for pneumoperitoneum and was confirmed by abdominal x ray examination (fig 2). At laparotomy, two small gastric perforations were identified with local areas of infarction. These were oversewn, with excellent results.

Neonatal gastric perforation is unusual but serious. Various causative factors, including prematurity and nCPAP, have been suggested. Both of these were present in our case. It is also possible that emboli from the umbilical catheter led to small areas of infarction of the stomach wall.

Transillumination is a quick and easy technique for diagnosing pneumoperitoneum, and obviates the need for frequent radiographs.

References

Renal fungal ball

Preterm infants are prone to fungal infections because of immaturity of their host defence systems (immunology and skin). Other risk factors include multiple antibiotic therapy, prolonged use of umbilical or percutaneous catheters, total parenteral nutrition, colonisation and/or past mucocutaneous candidiasis, low birth weight, endotracheal tube placement, and congenital malformation.

Common sites for invasive candidiasis are the renal system, eyes, brain, and heart. Diagnostic tests should include blood and urine cultures, renal ultrasound, ophthalmological assessment, cardiac ultrasound, and examination of cerebrospinal fluid.

Candiduria may indicate colonisation, but the presence of other clinical signs increases the risk of invasive candidiasis. Fungal ball is the commonest presentation of renal fungal disease. Clinical presentation may vary and can be obstructive, or non-obstructive, with renal failure.

A baby born at 28 weeks gestation was known to be colonised with Candida spp in the first weeks of life. The mother had declined routine antenatal care. The baby was ventilator dependent, with umbilical lines and received multiple broad spectrum antibiotics for possible bacterial sepsis.

After one month the baby developed thrombocytopenia and renal impairment. A renal ultrasound confirmed the presence of a solitary kidney with an echogenic mass.

Limited postmortem examination revealed multiple abscesses in the renal parenchyma, which grew Candida albicans only.

Invasive fungal infections in very low birthweight babies are currently the subject of a BPSU study (http://bpsu.inopsu.com/current.htm#Invasive).

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REFERENCE