Knee Surg Sports Traumatol Arthrosc (2012) 20:1766–1772
DOI 10.1007/s00167-011-1761-0

KNEE

Transfusion drains versus suction drains in total knee replacement: meta-analysis

Sheraz R. Markar · Gareth G. Jones · Alan Karthikesalingam · Nicholas Segaren · Rahul V. Patel

Received: 22 May 2011 / Accepted: 28 October 2011 / Published online: 10 November 2011

Abstract
Purpose The use of autologous blood transfusion drains in orthopaedic surgery has been the subject of debate for several years. The aim of this meta-analysis was to review the use of autologous blood transfusion drains in total knee replacement.
Methods The primary outcomes were as follows: the number of patients requiring homologous blood transfusion, pre-operative haemoglobin and post-operative haemoglobin days 5–7. The secondary outcome measures for the meta-analysis were drainage volume, length of hospital stay, average number of units transfused per patient, post-operative wound infection, and deep vein thrombosis.
Results Eight randomised controlled trials met the inclusion criteria and were included in this analysis. Autologous transfusion drains were associated with a decrease in the number of patients requiring post-operative blood transfusion (pooled odds ratio = 0.36, 95% CI = 0.15–0.85, $P = 0.02$), the number of units transfused per patient (weighted mean difference = −0.84 (95% CI = −1.13 to −0.56), $P < 0.0001$), and length of hospital stay (weighted mean difference = −0.25 (95% CI = −0.48 to −0.01), $P = 0.04$).
Conclusion The results of our study highlight both likely clinical and economic benefits within total knee replacement surgery. The clinical benefits of autologous transfusion drains in the total knee replacement surgery suggested by this meta-analysis include a reduced requirement for post-operative blood transfusion and a shorter length of hospital stay. However, further large-scale high-powered randomized controlled trials are recommended to further elucidate subtle effects of autologous drains on post-operative outcome following total knee replacement.
Level of evidence II.

Keywords Total knee replacement · Transfusion · Autologous

S. R. Markar (✉) · G. G. Jones · N. Segaren · R. V. Patel
Department of Trauma and Orthopaedic Surgery,
University College London Hospitals NHS Foundation Trust,
235 Euston Road, London NW1 2BU, UK
e-mail: sheraz_markar@hotmail.com

A. Karthikesalingam
Department of General Surgery, Chelsea and Westminster NHS Foundation Trust, London, UK

Introduction

Transfusion following knee arthroplasty is common, indeed a prospective study of 5,562 patients by Bierbaum et al. [6] observed a transfusion rate of thirty-nine per cent. The hazards associated with allogeneic transfusion are well documented and include the following: infection (viral and bacterial), haemolytic transfusion reactions, and transfusion-related lung injury [3, 23, 26]; hence the appeal of autologous blood. Furthermore, compared with pre-operative autologous blood donation and intra-operative cell salvage, the use of an autologous drain is relatively simple to implement, and potentially cost-effective.

A number of commercial autologous drains based on similar principles are available. They comprise a closed-suction system that collects blood via a filter (to reduce the risk of emboli). When full (or after a maximum of 6 h), the collecting vessel is detached (replaced if time allows), and the unwashed blood transfused via a standard giving set [11]. All blood must be transfused within 6 h of collection [4]. Some collecting vessels contain an acid-citrate-dextrose anticoagulant, although its benefit is questionable [13].

A number of prospective randomised trials have studied the use of autologous drains versus closed-suction drains in knee arthroplasty, with varying conclusions. The aim of this meta-analysis was to pool the data from these randomised controlled trials, in order to provide a substantiated judgement regarding the use of transfusion drains in total knee replacement surgery.

Materials and methods

A systematic literature search of Medline (1950–August 2010), Embase (1974–August 2010), Web of Science (1990–August 2010) and Cochrane Library (2009 Issue 2) databases was undertaken. The search terms: 'Total Knee Replacement', 'knee arthroplasty', and 'transfusion drains' and MeSH headings 'Arthroplasty' (MeSH), 'Knee' (MeSH), 'Surgical Drainage' (MeSH), and 'Transfusion' (MeSH) were used in combination with Boolean Operators AND or OR. The electronic search was supplemented by a hand search of published abstracts by relevant surgical societies and associations. Reference lists of all relevant studies were reviewed and the search included the Current Controlled Trials Register (http://www.controlled-trials.com).

Abstracts of these citations identified by the search were then scrutinised by two independent observers (SM and AK) in order to determine eligibility for inclusion in this meta-analysis. Studies were included if they met each of the following criteria: prospective randomised controlled trials, randomisation of patients into two groups: total knee replacement with transfusion drainage system (group 1) and standard suction drain system (group 2). Exclusion criteria comprised the following (by implication): trials with retrospective design, those without randomisation of patients into two relevant groups, together with studies focusing on a paediatric population, and those reporting an alternative drainage system.

The primary outcome measures for this meta-analysis were as follows: the number of patients requiring homologous blood transfusion, pre-operative haemoglobin and post-operative haemoglobin days 5–7. The secondary outcome measures for the meta-analysis were drainage volume, length of hospital stay, average number of units transfused per patient, post-operative wound infection and deep vein thrombosis (DVT).

Statistical analysis

Data from eligible trials were entered into a computerised spreadsheet for analysis. The quality of each trial was assessed using the Jadad scoring system [16]. The statistical analysis was performed using Statsdirect 2.5.7 (Statsdirect Ltd. UK). Weighted mean difference was calculated to assess the size of the effect of blood transfusion drains on continuous variables such as post-operative haemoglobin days 5–7, drainage volume, length of hospital stay, and average number of units transfused per patient. Pooled odds ratios were calculated to assess the size of the effect of blood transfusion drains on discrete variables such as number of patients requiring homologous transfusion, post-operative wound infection, haematoma, and DVT. Pooled outcome measures were determined using random-effects models as described by Der Simonian and Laird [9]. Heterogeneity amongst the trials was assessed by using Cochran Q statistic, a null hypothesis test in which $P < 0.05$ was taken to indicate the presence of significant heterogeneity. Cochran Q statistic is calculated as the weighted sum of squared differences between individual study effects and the pooled effect across studies, with the weights being those used in the pooling method. Q is distributed as a chi-square statistic with k (number of studies) minus 1 degree of freedom. The Egger test was used to assess the funnel plot for significant asymmetry, indicating possible publication or other biases. The Egger test is a test for the Y intercept = 0 from a linear regression of normalised effect estimate (estimate divided by its standard error) against precision (reciprocal of the standard error of the estimate). Results were calculated to two decimal place, where P values were non-significant, n.s. has been used to denote this.

Results

Following the literature search and appropriate screening, eight randomised trials that met the inclusion criteria were identified [1, 2, 5, 7, 14, 17, 19, 28]. Table 1 shows the basic demographic data for the studies included. Tables 2 and 3 show the primary and secondary outcomes, respectively, for each trial included.

Primary outcomes

Number of patients requiring homologous blood transfusion

All eight trials reported the number of patients requiring homologous blood transfusion [1, 2, 5, 7, 14, 17, 19, 28]. There was a significant increase in the number of patients requiring homologous blood transfusion in the suction drain group (group 2)—(pooled odds ratio = 0.36, 95% CI = 0.15–0.85, $P = 0.02$) (Fig. 1). There was statistical evidence of bias (Egger test = −6.34, $P = 0.02$). There was significant statistical heterogeneity (Cochran's Q = 31.69, $P < 0.0001$).

Table 1 Demographic data

Author	Pt No[a]	Pt No[b]	Age[a] (years)[c]	Age[b] (years)[c]	M:F ratio[a]	M:F ratio[b]
Abuzakuk [1]	52	52	–	–	–	–
Adalberth [2]	24	25	71.2 ± 2.2	72 ± 2.4	4:20	9:16
Amin [5]	92	86	70.3 ± 5.8	70.4 ± 5.4	43:49	49:47
Cheng [7]	26	34	72 ± 5.2	69.4 ± 4.8	6:20	12:22
Heddle [14]	39	40	69.3 ± 6.9	71 ± 9	14:25	14:26
Majkowski [17]	20	20	71.3	70.3	–	–
Newman [19]	35	35	–	–	–	–
Zacharopoulos [28]	30	30	69.2	70.2	6:24	7:23

[a] Autologous transfusion drain group
[b] Suction (non-transfusion) drain group
[c] Mean ± SD

Table 2 Primary outcomes

Author	No of pts requiring homologous BT[a]	No of pts requiring homologous BT[b]	Pre-op Hb[a] (g/dL)[c]	Pre-op Hb[b] (g/dL)[c]	Hb on day 5–7[a] (g/dL)[c]	Hb on day 5–7[a] (g/dL)[c]
Abuzakuk [1]	13	12	13.6 ± 1.5	13.5 ± 1.2	10.6 ± 1.5	10.1 ± 1.3
Adalberth [2]	8	8	13.8 ± 0.3	14.3 ± 1	11 ± 0.9	11.4 ± 0.9
Amin [5]	12	13	13.2 ± 1.2	13.4 ± 1.3	–	–
Cheng [7]	4	14	12.5 ± 5.5	12.8 ± 7.1	–	–
Heddle [14]	10	13	–	–	–	–
Majkowski [17]	7	19	–	–	–	–
Newman [19]	3	28	13.4 ± 1.2	13.2 ± 1.4	11.4 ± 1.4	10.9 ± 1.4
Zacharopoulos [28]	5	10	–	–	–	–

BT Blood Transfusion, *Hb* Haemoglobin
[a] Autologous transfusion drain group
[b] Suction (non-transfusion) drain group
[c] Mean ± SD

Table 3 Secondary outcomes

Author	Drainage volume[a] (mL)[c]	Drainage volume[b] (mL)[c]	Length of hospital stay[a] (days)[c]	Length of hospital stay[b] (days)[c]	Average number of blood units transfused per patient[a] (units)[c]	Average number of blood units transfused per patient[b] (units)[c]	Post-op wound infection[a]	Post-op wound infection[b]	Post-op DVT[a]	Post-op DVT[b]
Abuzakuk [1]	673 ± 355	867 ± 434	8.1 ± 2.4	8.3 ± 2.8	–	–	–	–	–	–
Adalberth [2]	881 ± 18.5	737 ± 18.5	11 ± 1.4	11.8 ± 1.7	–	–	–	–	–	–
Amin [5]	–	–	6.6 ± 3.3	7 ± 3.6	–	–	3	2	1	2
Cheng [7]	639 ± 29.3	683 ± 43.8	–	–	0.3 ± 1	1.2 ± 2	–	–	–	–
Heddle [14]	1,006 ± 534	1,008 ± 484	–	–	0.4 ± 0.8	1.2 ± 1	–	–	–	–
Majkowski [17]	1,020 ± 540	1,140 ± 513	–	–	–	–	1	0	2	2
Newman [19]	896 ± 545	891 ± 401	12.6 ± 3.8	15.2 ± 5.3	0 ± 1.7	2 ± 2	–	–	–	–
Zacharopoulos [28]	808 ± 38.1	564 ± 33.9	–	–			–	–	–	–

[a] Autologous transfusion drain group
[b] Suction (non-transfusion) drain group
[c] Mean ± SD

Pre-operative Haemoglobin

Five trials reported the pre-operative haemoglobin of the patients included in the trial [1, 2, 5, 7, 19]. There was no significant pre-operative difference in Hb between the groups (weighted mean difference = −0.10 (95% CI = −0.33 to 0.13), P = n.s.) (Fig. 2). There was no statistical evidence of heterogeneity (Cochran's Q = 5.69, P = n.s.). There was no statistical evidence of bias (Egger test = −1.01, P = n.s.)

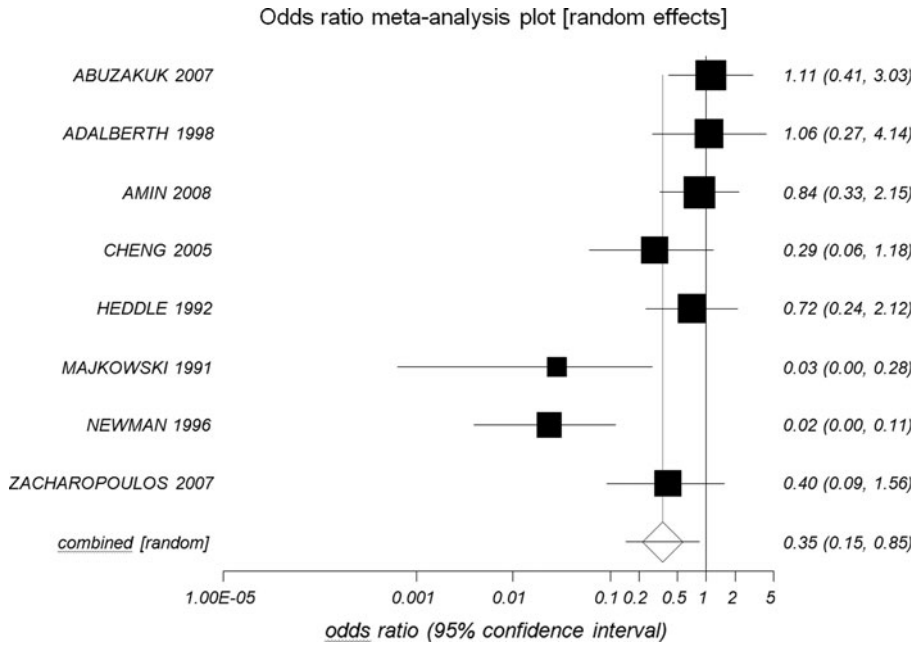

Fig. 1 Forrest plot for number of patients requiring transfusion

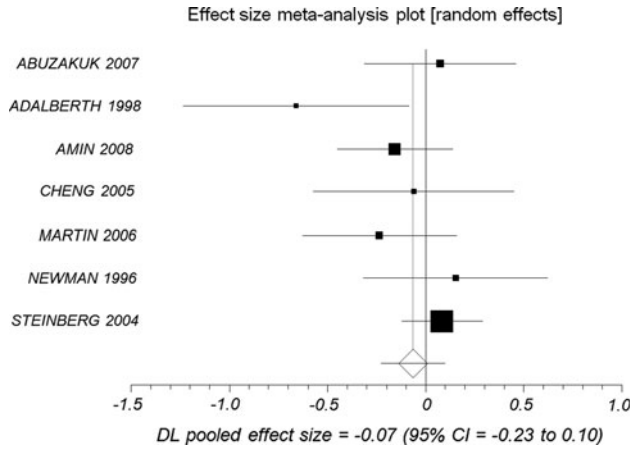

Fig. 2 Forrest plot for number of pre-operative haemoglobin

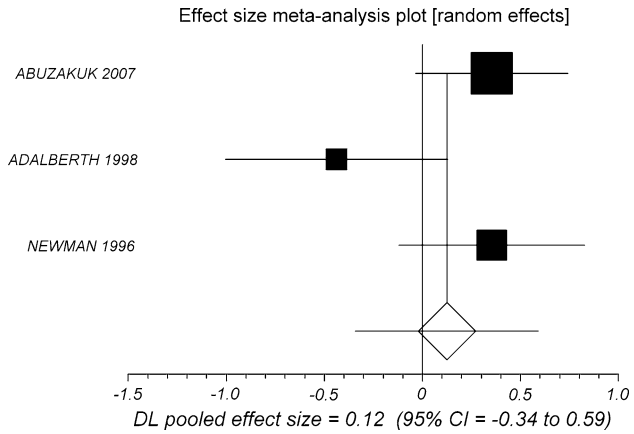

Fig. 3 Forrest plot for post-operative haemoglobin 5–7

Haemoglobin on post-operative day 5–7

Three trials reported the post-operative haemoglobin level of patients on day 5, day 6, or day 7 [1, 2, 19]. There was no significant difference between the groups in terms of post-operative Hb at days 5–7 (weighted mean difference = 0.12 (95% CI = −0.34 to 0.59), P = n.s.) (Fig. 3). There was no statistical evidence of heterogeneity (Cochran Q = 5.85, P = n.s.). Too few trials meant insufficient data for the calculation of statistical bias.

Secondary outcomes

Drainage volume

Seven trials reported the total volume of drainage post-operatively [1, 2, 7, 14, 17, 19, 28]. There was a significantly reduced drainage volume in the suction drain group (group 2) (weighted mean difference = 1.55 (95% CI = 0.25–2.85), P = 0.02) (Fig. 4). There was evidence of statistical bias (Egger test = 12.78, P = 0.009). There was significant statistical heterogeneity (Cochran Q = 211.23, $P < 0.0001$).

Length of hospital stay

Four trials reported the length of hospital stay as an outcome for their study [1, 2, 5, 28]. There was a significantly longer length of hospital stay in the suction drain group (group 2) (weighted mean difference = −0.25 (95% CI = −0.48 to −0.01), P = 0.04) (Fig. 5). There was no statistical heterogeneity (Cochran Q = 3.90, P = n.s.). There was no statistical bias (Egger bias = −3.38, P = n.s.).

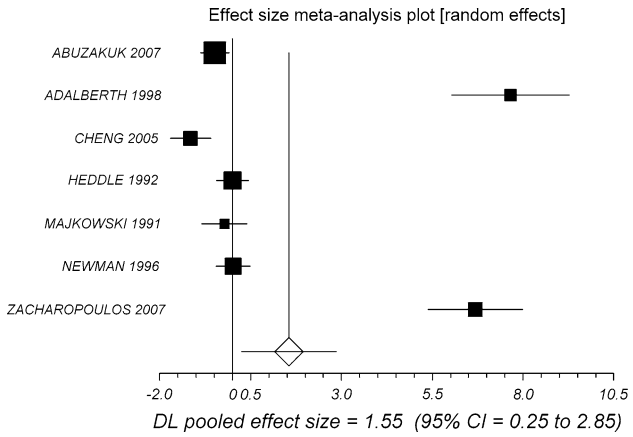

Fig. 4 Forrest plot for drainage volume

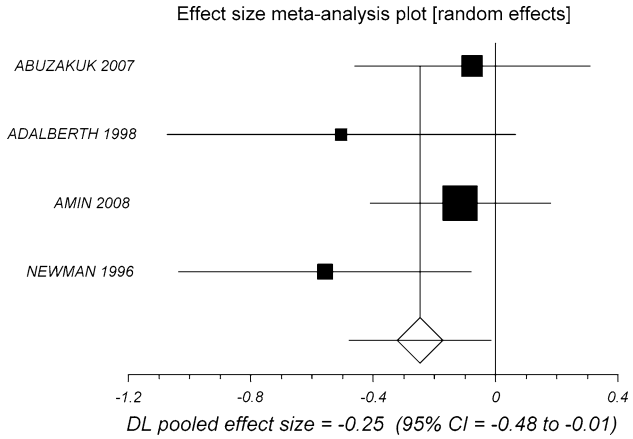

Fig. 5 Forrest plot for length of hospital stay

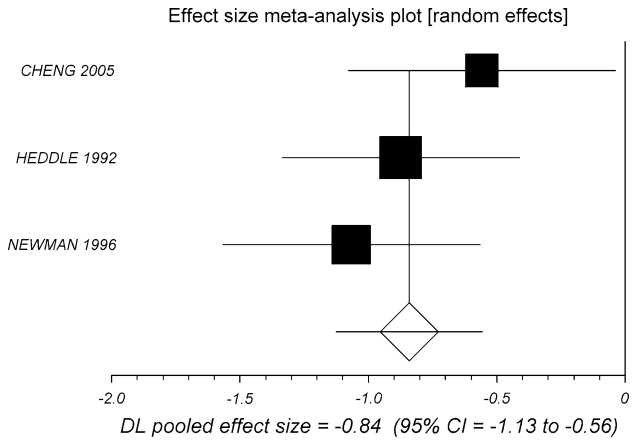

Fig. 6 Forrest plot for average number of units of blood transfused per patient

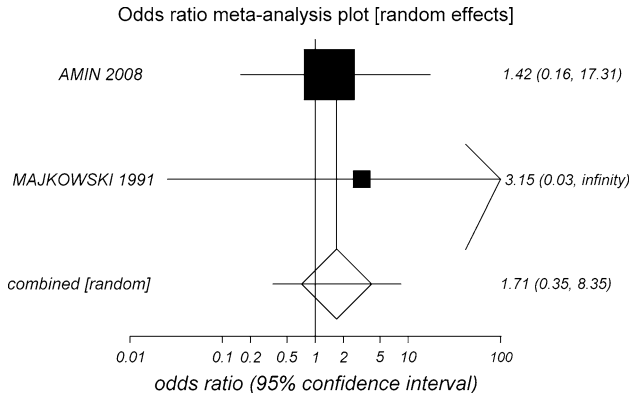

Fig. 7 Forrest plot for incidence of post-operative wound infection

Average number of units of blood transfused per patient

Three trials reported the average number of units of blood transfused per patient [7, 14, 19]. There was a significantly increased number of units of blood transfused per patient in the suction drain group (weighted mean difference = −0.84 (95% CI = −1.13 to −0.56), $P < 0.0001$) (Fig. 6). There was no significant statistical heterogeneity (Cochran Q = 1.93, P = n.s.). Too few trials provided data for the calculation of statistical bias.

Post-operative wound infection

Two trials reported the incidence of post-operative wound infection [5, 17]. There was no significant difference between the groups in the incidence of post-operative wound infection (pooled odds ratio = 1.71 (95% CI = 0.35–8.35) P = n.s.) (Fig. 7). There was no evidence of statistical heterogeneity (Cochran Q = 0.18, P = n.s.). There was insufficient data for the calculation of statistical bias.

Post-operative deep vein thrombosis

Two trials reported the incidence of post-operative DVT, but failed to describe the method of diagnosis [5, 17]. There was no significant difference in the incidence of post-operative DVT between the two groups (pooled odds ratio = 0.72 (95% CI = 0.15–3.47), P = n.s.) (Fig. 8). There was no evidence of statistical heterogeneity (Cochran Q = 0.23, P = n.s.). There was insufficient data for the calculation of statistical bias.

Discussion

The most important result of this present meta-analysis was a significant increase in the number of patients requiring homologous blood transfusion in the suction drain group (group 2) (pooled odds ratio = 0.36, 95% CI = 0.15–0.85, $P = 0.02$). Additional significant findings included an increased number of units of blood transfused per patient

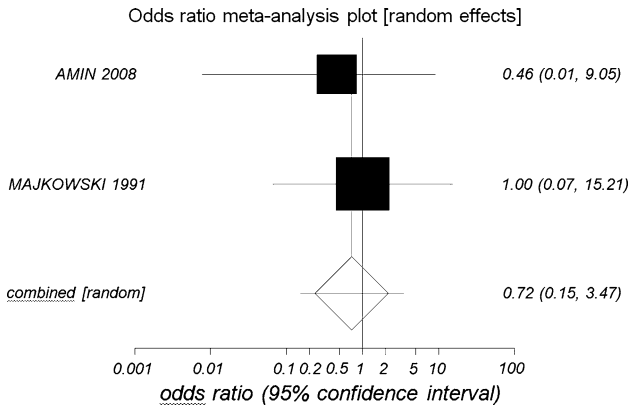

Fig. 8 Forrest plot for incidence of post-operative deep vein thrombosis

(weighted mean difference = −0.84 (95% CI = −1.13 to −0.56), $P < 0.0001$) and an increased length of hospital stay (weighted mean difference = −0.25 (95% CI = −0.48 to −0.01), $P = 0.04$) in the suction drain group.

The benefits of a reduced requirement for post-operative homologous blood transfusion—regarding both number of patients and number of units per patient—are clear. Homologous blood transfusion has associated risks: viral infection (e.g. hepatitis, vCJD, and human immunodeficiency virus), bacterial infection, haemolytic transfusion reactions, and transfusion-related lung injury [10, 27]. Furthermore, homologous blood transfusion represents a significant cost; in the United Kingdom one unit of blood currently costs £124 [18].

Given the increased transfusion requirement, it was interesting to find no significant difference between the groups with regard to post-operative haemoglobin level on days 5–7. Whilst understandable, given that the majority of post-operative transfusions will have occurred by this stage, it underlines that the auto-transfusion group did not have haemoglobin levels clustered in the lower range of normal (which would produce the observed reduction in homologous transfusion rates but may be detrimental to rehabilitation). Regrettably, insufficient day 1 haemoglobin data were available for the analysis.

Of note is that analysis of secondary outcome measures also revealed a significantly longer length of hospital stay in the suction drain group (group 2) (weighted mean difference = −0.25 (95% CI = −0.48 to −0.01), $P = 0.04$). It remains uncertain whether this lengthened in-patient stay is directly related to an increased requirement for homologous transfusion, or related to other confounding factors, for example medical co-morbidities, length of operation etc. Interestingly, in joint replacement surgery, autologous transfusion is associated with an increased activity of polymorphonuclear leucocytes [15], and increased number of natural killer precursor cells (when compared to non-transfused, homologous non-leucodepleted blood, homologous leucodepleted blood, and autologous predepositied blood) [12]. A possible explanation of the demonstrated reduction in post-operative stay associated with the use of autologous transfusion drains is that this may be the indirect result of the putative immunostimulant effect of autotransfusion.

This meta-analysis indicates that autologous transfusion drains may have the potential to provide cost savings, without compromising clinical safety; arguably a prudent measure in an age of austerity. It is speculated that this potential gain would hold true after factoring in product and implementation costs. Only one of the studies [28] included in this meta-analysis made a financial comparison between the two groups; it demonstrated a 36% reduction in transfusion cost in the autologous drain group. On the evidence of this paper's findings, further randomised trials analysing the cost-effectiveness of autologous transfusion drains in total knee replacement surgery are required.

The potential risks of re-infusing blood drained during surgery have been investigated. Decreased platelet counts, pH levels and clotting factors, and an increase in fibrin degradation products have all been reported [8, 21]. The American Association of Blood Banks [6] propose that a cytokine cascade may be activated in drained blood that could pose additional problems (e.g. febrile reactions) if allowed to rise to the higher levels observed more than 6 h after bleeding [24]. This is supported by Faris et al. [11] who demonstrated that reinfusion of blood should begin within 6 h of collection to minimise the potential for febrile reactions; this has now become standard procedure and was adhered to by all the papers in this analysis.

There was no significant difference between the groups for further secondary outcomes: incidence of post-operative wound infection (pooled odds ratio = 1.71 (95% CI = 0.35–8.35), P = n.s.) and incidence of post-operative DVT (pooled odds ratio = 0.72 (95% CI = −0.15–3.47), P = n.s.).

Confounding variables within the trials studied impact upon the reliability and validity of findings. For example, the timing of randomisation is important; this should be done at the end of an operation, when the drain is about to be inserted (observed in only three studies [2, 7, 14]). Deliberate hypotensive anaesthesia is thought to reduce blood loss in arthroplasty [20]. Unfortunately only one study reported the use of a consistent anaesthesia [2], whilst five papers made no mention of their anaesthetic method. Two studies failed to record whether all prostheses were cemented [17, 28]. Early tourniquet release for haemostasis has been found to increase blood loss [22]; three studies included in our meta-analysis deflated the tourniquet prior to closure, whilst three were deflated after applying the dressing (two papers failed to document

timing of deflation). Similarly the timing of drain opening has been proposed to affect blood loss [25], but this is only documented in two of the studies included [2, 5]. Different transfusion criteria were employed in each study; Zacharopoulos et al. [28] intra-operatively transfused one unit of blood to all patients in their control group (i.e. with a standard drain).

This meta-analysis is limited by the heterogeneity in study design and outcome measurement reported in the included randomised controlled trials as reflected by the wide confidence intervals for several of the results gained. Furthermore, these trials are underpowered to show conclusive statistically significant differences between the groups. However, despite these limitations, this meta-analysis does provide the highest level of evidence to date and does suggest a clinical benefit to the use of autologous transfusion drains in total knee replacement surgery.

Conclusion

This meta-analysis of randomised control trials has demonstrated the likely clinical benefits of autologous blood transfusion drains in total knee arthroplasty that is reduced post-operative transfusion requirement, and shorter length of hospital stay. However, due to methodological limitations in a number of the studies, further, standardised large-scale randomized controlled trials are recommended.

References

1. Abuzakuk T, Senthil Kumar V, Shenava Y, Bulstrode C, Skinner JA, Cannon SR, Briggs TW (2007) Autotransfusion drains in total knee replacement. Are they alternatives to homologous transfusion? Int Orthop 31:235–239
2. Adalberth G, Bystrom S, Kolstad K, Mallmin H, Milbrink J (1998) Post-operative drainage of knee arthroplasty is not necessary: a randomized study of 90 patients. Acta Orthop 69:475–478
3. Alter HJ, Klein HG (2008) The hazards of blood transfusion in historical perspective. Blood 112:2617–2625
4. American Association of Blood Banks (2009). Guidance for the standards of perioperative autologous blood collection and administration, 4th edn, pp 17–21
5. Amin A, Watson A, Mangwani J, Nawabi D, Ahluwalia R, Loeffler M (2008) A prospective randomised controlled trial of autologous retransfusion in total knee replacement. J Bone Joint Surg Br 90:451–454
6. Bierbaum BE, Callaghan JJ, Galante JO, Rubash HE, Tooms RE, Welch RB (1999) An analysis of blood management in patients having a total hip or knee arthroplasty. J Bone Joint Surg Am 81:2–10
7. Cheng SC, Hung TS, Tse PY (2005) Investigation of the use of drained blood reinfusion after total knee arthroplasty: a prospective randomised controlled study. J Orthop Surg (Hong Kong) 13:120–124
8. Dalen T, Brostrom LA, Engstrom KG (1997) Autotransfusion after total knee arthroplasty, effects on blood cells, plasma chemistry and whole blood rheology. J Athroplasty 12:517–525
9. DerSimonian R, Laird N (1986) Meta-analysis in clinical trials. Control Clin Trials 7:177–188
10. Dodd RY (1992) The risk of transfusion transmitted infection. N Engl J Med 327:419–421
11. Faris PM, Ritter MA, Keating EM, Valeri CR (1991) Unwashed filtered and shed blood collected after knee and hip arthroplasties. A source of autologous red blood cells. J Bone Joint Surg Am 73:1169–1178
12. Gharenbaghian A, Haque KM, Truman C, Evans R, Morse R, Newman J, Bannister G, Rogers C, Bradley BA (2004) Effect of autologous salvaged blood on post-operative natural killer cell precursor frequency. Lancet 363:1025–1030
13. Handel M, Winkler J, Hornlein RF, Northoff H, Heeg P, Sell S (2002) Influence of acid-citrate-dextrose anticoagulant on blood quality in retransfusion systems after total knee arthroplasty. Arch Orthop Trauma Surg 122:269–273
14. Heddle NM, Brox WT, Klama LN, Dickson LL, Levine MN (1992) A randomized trial on the efficacy of autologous blood drainage and transfusion device in patients undergoing elective knee arthroplasty. Transfusion 32:742–746
15. Iorwerth A, Wilson C, Topley N, Pallister I (2003) Neutrophil activity in total knee replacement: implications in preventing post-arthroplasty infection. Knee 10:111–113
16. Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ (1996) Assessing the quality of reports of randomized clinical trials: is blinding necessary? Control Clin Trials 17:1–12
17. Majowski RS, Currie IC, Newman JH (1991) Post-operative collection and reinfusion of autologous blood in total knee arthroplasty. Ann R Coll Surg Engl 73:381–384
18. National Health Service Blood and Transplant Annual Report 2009–2010
19. Newman JH, Bowers M, Murphy J (1997) The clinical advantages of autologous transfusion. A randomized, controlled study after knee replacement. J Bone Joint Surg Br 79:630–632
20. Paul JE, Ling E, Lalonde C, Thabane L (2007) Deliberate hypotension in orthopaedic surgery reduces blood loss and transfusion requirements: a meta-analysis of randomized controlled trials. Can J Anaesth 54:799–810
21. Peter VK, Radford M, Matthews MG (2001) Re-transfusion of autologous blood from wound drains: the means of reducing transfusion requirements in total knee arthroplasty. Knee 8:321–323
22. Rama KR, Apsingi S, Poovali S, Jetti A (2007) Timing of tourniquet release in knee arthroplasty. Meta-analysis of randomized controlled trials. J Bone Joint Surg Am 89:699–705
23. Sandler SG, Rassai N (2003) Risks of blood transfusion and their prevention. Clin Adv Hematol Oncol 1:307–313
24. Stowell CP, Girodano GF, Kiss J, Renner SW, Weiskopf RB, Thrurer R (1997). Guidelines for blood recovery and reinfusion in surgery and trauma. American Associated for Blood Banks, Bethesda, Maryland 2084–2749 USA; 1800.406
25. Tai TW, Yang CY, Jou IM, Lai KA, Chen CH (2010) Temporary drainage clamping after total knee arthroplasty a meta-analysis of randomized controlled trials. J Arthroplasty 25:1240–1245
26. Varney SJ, Guest JF (2003) The annual cost of blood transfusions in the UK. Transfus Med 13:205–218
27. Waymack JP, Yurt RW (1990) Effect of blood transfusions on immune function. The effect on the inflammatory response. J Surg Res 48:147–153
28. Zacharopoulos A, Apostolopoulous A, Kyriakidis A (2007) The effectiveness of reinfusion after total knee replacement. A prospective randomised controlled study. Int Orthop 31:303–308