This systematic review consists of two parts:

1. **Thermal policies in the perioperative setting – Active perioperative warming or not?**

2. **Thermal policies in the perioperative setting – Which type of active perioperative warming is most effective?**

Thermal policies in the perioperative setting – Active perioperative warming or not?

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The following question was answered by a systematic review of the literature:
Does active perioperative warming compared to no active perioperative warming reduce the occurrence of postoperative mortality and surgical site infection?

Study population: patients undergoing surgery
Comparison: active perioperative warming versus no active perioperative warming
Outcome: postoperative mortality, surgical site infection

Perioperative was defined as the period of time extending from about two hours before surgery until the time the patient leaves the recovery room.

Methods

Data sources

Publications were retrieved by a search of Medline, the Cochrane Library and Embase up to 16 June 2009. The search strategy in Cochrane was: (normothermia OR hypothermia OR warming OR thermal care OR "Hypothermia"[Majr] OR "Hot Temperature/therapeutic use"[Majr]) AND
(Postoperative Care OR Preoperative Care OR Intraoperative Care OR Perioperative Care OR Postoperative OR Preoperative OR Intraoperative OR Perioperative) AND ("surgical wound infection"[Mesh] OR Postoperative Complications OR "wound infection" OR mortality); in Embase: (normothermia.ti OR hypothermia.ti OR exp *Body Temperature/ OR exp *Hypothermia/ OR warming.ti OR exp * High Temperature Procedures/ OR thermal care.ti) AND (Perioperative Period OR exp Postoperative Period/ OR Preoperative Period/ OR Intraoperative Period/ OR Postoperative OR Preoperative OR Intraoperative OR Perioperative) AND (Exp Surgical Infection/ OR exp Postoperative Complication/ OR Postoperative Complication*.mp OR wound infection.mp OR mortality.mp OR exp Mortality/) AND (meta analysis/ or randomized

controlled trial/ or "systematic review"/ OR random*.ti). To identify randomised controlled trials in Medline the following search strategy was used: (normothermia[ti] OR hypothermia[ti] OR "Hypothermia"[Majr] OR "Hot Temperature/therapeutic use"[Majr] OR warming[ti] OR "thermal care"[ti]) AND (Postoperative Care OR Preoperative Care OR Intraoperative Care OR Perioperative Care OR Postoperative OR Preoperative OR Intraoperative OR Perioperative) AND ("surgical wound infection"[Mesh] OR Postoperative Complications OR "wound infection" OR mortality) AND ("Randomized Controlled Trial "[Publication Type] OR randomised[ti] OR randomized[ti] OR random*[ti] OR systematic[sb]) NOT (animal [mh] NOT human [mh]). Additionally, all reference lists of identified trials were examined.

Selection criteria

All randomised and quasi-randomised trials comparing active perioperative warming therapy versus no active perioperative warming therapy and postoperative mortality or surgical site infection as the outcome measures were included.

Review methods

Data were extracted by two reviewers independently and compared. Disagreements were resolved by discussion. Data from the original publications were used to calculate the relative risk of dichotomous outcomes. Data for similar outcomes were combined in the analysis where appropriate, using a random-effects model. The quality of evidence per outcome was assessed by using the Grade system [1].

Results

One hundred and twenty-three potentially relevant studies were initially identified by our search. By judgment of titles and abstracts, two parallel-group randomised controlled trials fulfilled the selection criteria and were included in the review [2, 3].

Quality assessment

See Table 1

Study population, interventions and outcome definitions

See Table 2

Grade Evidence profil

See table 3 for patients undergoing clean surgery;

See table 4 for patients undergoing major colorectal surgery;

Summary estimates of associations between treatment and control group

See Figure 1 for patients undergoing clean surgery;

See Figure 2a and 2b for patients undergoing major colorectal surgery;

Table 1 Data on quality assessment

	Concealment of allocation	**Double blind**	**Description of dropouts (%)**	**Analysis by intention-to-treat**	**Stopping trial early to benefit**	**Selective reporting of events**
Kurz 1996	Adequate	No*	Adequate (0%)	Yes	Yes	No
Melling 2001	Adequate	No*	Adequate (1.2%)	No	No	No

* Blinded outcome assessor

Table 2 Study populations, interventions and outcomes

Study	Study participants	Treatment group (T); control group (C)	Outcomes (and definitions)	Baseline risks	End of study protocol	Notes
Kurz 1996	Adults undergoing elective major colorectal surgery	T: active systemic warming* to maintain patients' core temperatures near 36.5 C C: no active systemic warming; patient's core temperature was allowed to decrease to approximately 34.5 C *Systemic warming: During surgery warming of intravenous fluids and a forced-air cover over the upper body of the patient delivering air at 40 C.	Mortality within 1 month after surgery T: 2 / 104 C: 2 / 96 Surgical site infection, defined as 1) pus could be expressed from the surgical incision or aspirated from a loculated mass inside the wound, and 2) a culture was positive for pathogenetic bacteria. T: 6 / 104 C: 18 / 96	Mortality: 2.1% Surgical site infection: 18.8%	Until 2 weeks after discharge	Mean final intraoperative core temperature: T: $36.6^0 \pm 0.5^0$ C C: 34.7 ± 0.6^0 C
Melling 2001	Adults undergoing clean surgery (elective hernia repair, varicose vein surgery, breast surgery that would result in a scar longer than 3 cm in length)	T I: local warming* T II: systemic warming** C: no warming *Local warming: Until just before surgery a minimum	Surgical site infection, defined as purulent discharge or painful erythema that lasted for 5 days and was treated with antibiotics within 6 weeks of surgery. T1: 5 / 138 T2: 8 / 139 C: 19 / 139	Mortality: NR Surgical site infection: 13.7%	Until 6 weeks after surgery	Core temperature before and after surgery of the different randomization groups were not reported

		30 minutes preoperative warming of the planned wound area by using a non-contact, radiant heat dressing. **Systemic warming: Until just before surgery a minimum 30 minutes preoperative warming to the whole body by using a forced-air, warming blanket.	Mortality NR			

Table 3 Grade evidence profil' for the question 'Should active perioperative warming versus no warming be used in patients undergoing clean surgery?'

Quality assessment							Summary of findings					Importance
							No of patients		Effect		Quality	
No of studies	Design	Limitations	Inconsistency	Indirectness	Imprecision	Other considerations	systemic or local perioperative warming	no warming	Relative (95% CI)	Absolute		
Mortality - not reported												
0												CRITICAL
Surgical site infection (follow-up 6 weeks[1])												
1	randomised trial	no serious limitations	no serious inconsistency	serious[2]	no serious imprecision	none	13/277 (4.7%)	19/139 (13.7%)	RR 0.34 (0.17 to 0.67)	90 fewer per 1000 (from 45 fewer to 114 fewer)	+++O MODERATE	CRITICAL

[1] Patients followed until 6 weeks after surgery
[2] Baseline risk for surgical site infection much higher than in the Dutch population undergoing clean surgery (PREZIES).

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

Table 4 Grade evidence profil' for the question 'Should active perioperative warming versus no warming be used in patients undergoing major colorectal surgery?'

Quality assessment							Summary of findings					
							No of patients		Effect			
No of studies	Design	Limitations	Inconsistency	Indirectness	Imprecision	Other considerations	systemic or local perioperative warming	no warming	Relative (95% CI)	Absolute	Quality	Importance
Mortality (follow-up 1 months[1])												
1	randomised trial	no serious limitations	no serious inconsistency	no serious indirectness	very serious[2]	none	2/104 (1.9%)	2/96 (2.1%)	RR 0.92 (0.13 to 6.42)	2 fewer per 1000 (from 18 fewer to 114 more)	++OO LOW	CRITICAL
Surgical site infection (follow-up 2 weeks[3])												
1	randomised trial	no serious limitations	no serious inconsistency	no serious indirectness	no serious imprecision	none	6/104 (5.8%)	18/96 (18.8%)	RR 0.31 (0.13 to 0.74)	130 fewer per 1000 (from 49 fewer to 164 fewer)	++++ HIGH	CRITICAL

[1] Mortality within 1 month after surgery
[2] The 95% CI includes negligible effect, benefit and harm
[3] Until 2 weeks after surgery or after discharge (this is unclear in the original article)

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

Figure 1 Summary estimates of association between systemic or local warming and no warming before short duration clean surgery; outcome: surgical site infection

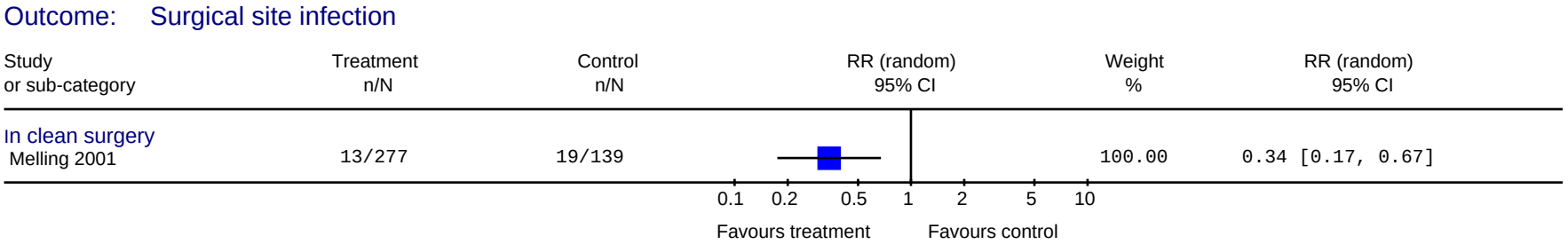


Figure 2a Summary estimates of association between systemic intra-operative warming and no warming in patients undergoing major colorectal surgery; outcome: mortality

Outcome: Mortality

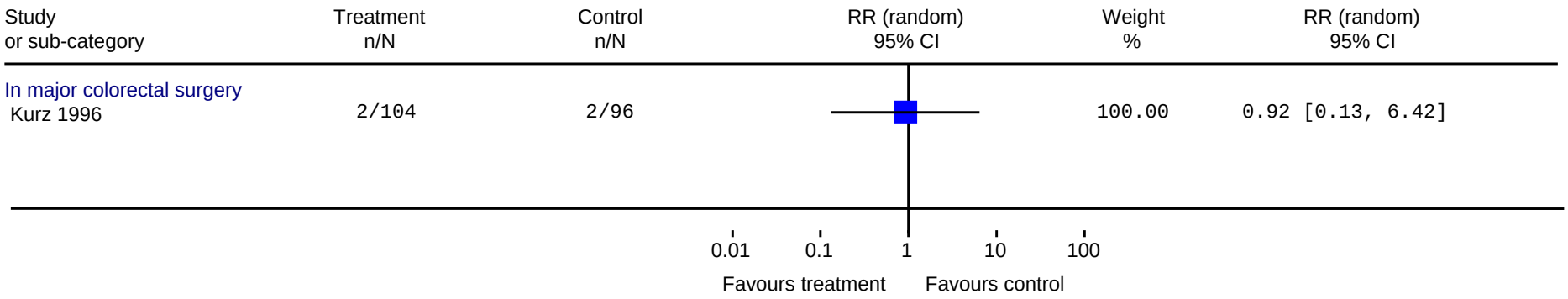
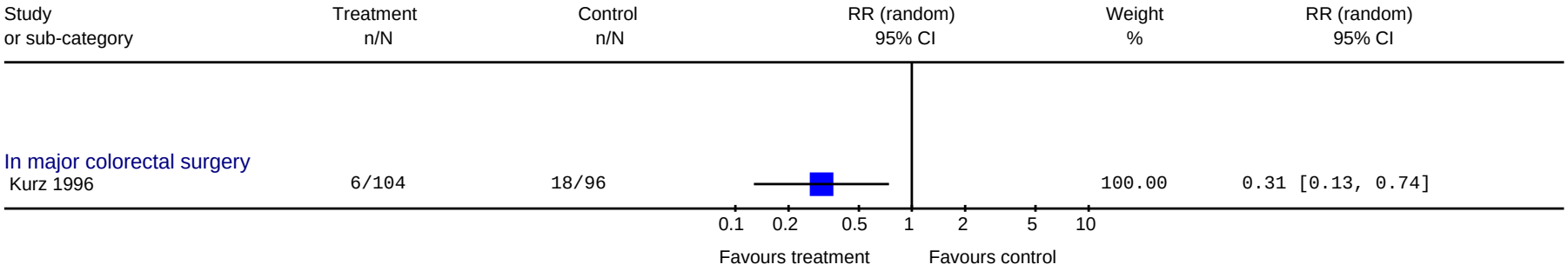


Figure 2b Summary estimates of association between systemic intra-operative warming and no warming in patients undergoing major colorectal surgery; outcome: surgical site infection

Outcome: Surgical site infection



Comments

None

Conclusion

a) For patients undergoing clean surgery (Table 3; Figure 1)

There is moderate evidence that local or systemic warming 30 minutes prior to short duration clean surgery compared to no local or systemic warming before short duration clean surgery reduces the rate of surgical site infection. There is no scientific evidence of the effect of local or systemic warming on mortality. A single good quality trial addressed this issue. In the treatment group, at least 30 minutes before surgery all patients were systemically warmed by using a forced-air warming blanket or locally warmed by using a non-contact, radiant heat dressing.

b) For patients undergoing major abdominal surgery (Table 4; Figures 2a and 2b)

There is low evidence that intra-operative warming compared to no intra-operative warming reduces mortality. There is high evidence that intra-operative warming compared to no intra-operative warming reduces the rate of surgical site infection. A single good quality trial addressed this issue. In the treatment group, the upper bodies of patients undergoing major abdominal surgery were systemically warmed to maintain patients' core temperatures near 36.5 by using a forced-air warming blanket.

Reference list

1. Atkins D, Best D, Briss PA et al. Grading quality of evidence and strength of recommendations. *BMJ* 2004; **328**: 1490.
2. Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. *N Engl J Med* 1996; **334**:1209-15.
3. Melling AC, Baqar A, Scott EM, Leaper DJ. Effects of preoperative warming on the incidence of wound infection after clean surgery: a randomised controlled trial. *Lancet* 2001; **358**:876-80.

Thermal policies in the perioperative setting - Which type of active perioperative warming is most effective?

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[3] Department of Infectious Diseases, Leiden University Medical Center

The following question was answered by a systematic review of the literature:
Which type of active perioperative warming is most effective in reducing mortality and surgical site infection?

Study population: patients undergoing surgery
Comparison: active perioperative warming versus another type of active perioperative warming therapy
Outcome: postoperative mortality, surgical site infection

Perioperative was defined as the period of time extending from about two hours before surgery until the time the patient leaves the recovery room.

Methods
Data sources
Publications were retrieved by a search of Medline, the Cochrane Library and Embase up to 16 June 2009. The search strategy in Cochrane was: (normothermia OR hypothermia OR warming OR thermal care OR "Hypothermia"[Majr] OR "Hot Temperature/therapeutic use"[Majr]) AND (Postoperative Care OR Preoperative Care OR Intraoperative Care OR Perioperative Care OR Postoperative OR Preoperative OR Intraoperative OR Perioperative) AND ("surgical wound infection"[Mesh] OR Postoperative Complications OR "wound infection" OR mortality); in Embase: (normothermia.ti OR hypothermia.ti OR exp *Body Temperature/ OR exp *Hypothermia/ OR warming.ti OR exp * High Temperature Procedures/ OR thermal care.ti) AND (Perioperative Period OR exp Postoperative Period/ OR Preoperative Period/ OR Intraoperative Period/ OR Postoperative OR Preoperative OR Intraoperative OR Perioperative) AND (Exp Surgical Infection/ OR exp Postoperative Complication/ OR Postoperative Complication*.mp OR wound infection.mp OR

mortality.mp OR exp Mortality/) AND (meta analysis/ or randomized controlled trial/ or "systematic review"/ OR random*.ti). To identify randomised controlled trials in Medline the following search strategy was used: (normothermia[ti] OR hypothermia[ti] OR "Hypothermia"[Majr] OR "Hot Temperature/therapeutic use"[Majr] OR warming[ti] OR "thermal care"[ti]) AND (Postoperative Care OR Preoperative Care OR Intraoperative Care OR Perioperative Care OR Postoperative OR Preoperative OR Intraoperative OR Perioperative) AND ("surgical wound infection"[Mesh] OR Postoperative Complications OR "wound infection" OR mortality) AND ("Randomized Controlled Trial "[Publication Type] OR randomised[ti] OR randomized[ti] OR random*[ti] OR systematic[sb]) NOT (animal [mh] NOT human [mh]). Additionally, all reference lists of identified trials were examined.

Selection criteria

All randomised and quasi-randomised trials comparing one type of active perioperative warming versus another type of active perioperative warming and postoperative mortality or surgical site infection as the outcome measures were included.

Review methods

Data were extracted by two reviewers independently and compared. Disagreements were resolved by discussion. Data from the original publications were used to calculate the relative risk of dichotomous outcomes. Data for similar outcomes were combined in the analysis where appropriate, using a random-effects model. The quality of evidence per outcome was assessed by using the Grade system [1].

Results

One hundred and twenty-three potentially relevant studies were initially identified by our search. By judgment of titles and abstracts, one parallel-group randomised controlled trial fulfilled the selection criteria and was included in the review [2].

Quality assessment

See Table 1

Study population, interventions and outcome definitions

See Table 2

Grade Evidence profil

See table 3

Summary estimates of associations between treatment and control group

See Figure 1 and 2

Table 1 Data on quality assessment

	Concealment of allocation	Double blind	Description of dropouts (%)	Analysis by intention-to-treat	Stopping trial early to benefit	Selective reporting of events
Wong 2007	Adequate	No*	Adequate (0%)	Yes	No	No

*Blinded: 1. Blinded outcome assessor who evaluated patients' surgical wounds until end of study protocol; 2. Blinded senior surgeons who decided when to begin feeding after surgery, remove sutures and discharge from hospital;

Table 2 Study populations, interventions and outcomes

Study	Study participants	Treatment group (T); control group (C)	Outcomes (and definitions)	Baseline risks	End of study protocol	Notes
Wong 2007	Adults undergoing elective major open abdominal surgery requiring bowel resection, with or without anastomosis	T: extra systemic warming* C: systemic warming** *Extra systemic warming: Standard systemic warming plus warming 2h before and after surgery by using a conductive carbon polymer mattress (40^0C) **Standard systemic warming: Systemic warming during surgery by using a forced-air warming device set at 40^0 and with a fluid warmer	Mortality T: 1 / 47 C: 2 / 56 Surgical site infection, defined as 1) pus could be expressed from the surgical incision or aspirated from a loculated mass inside the wound, 2) a culture was positive for pathogenetic bacteria, 3) pain at the surgical site, 4) tenderness at the surgical site, 5) localized zwelling at the surgical site, 6) redness at the surgical site, 7) temperature, or 8) the treating medical practitioner had diagnosed an wound infection and started antibiotics T: 6 / 47 C: 15 / 56	Mortality 3.6% Surgical site infection 26, 8%	Until 6-8 weeks after surgery	Authors controlled body temperatures before and immediately after surgery by using a tympanic thermometer; during surgery by using a nasopharyngeal temperature probe; Median core temperature before start surgery: T: 36.4 (35.1 – 37.4) C: 36.0 (35.1 – 36.9) Median core temperature immediately after surgery: T: 36.3 (34.3 – 38.1) C: 36.2 (34.3 – 37.9)

Table 3 Grade evidence profil'

Quality assessment							Summary of findings					Importance
							No of patients		Effect			
No of studies	Design	Limitations	Inconsistency	Indirectness	Imprecision	Other considerations	perioperative warming A	perioperative warming B	Relative (95% CI)	Absolute	Quality	
Mortality (follow-up 6-8 weeks[1])												
1	randomised trial	no serious limitations	no serious inconsistency	no serious indirectness	very serious[2]	none	1/47 (2.1%)[3]	2/56 (3.6%)[4]	RR 0.60 (0.06 to 6.37)	14 fewer per 1000 (from 34 fewer to 193 more)	++OO LOW	CRITICAL
Surgical site infection (follow-up 6-8 weeks[1])												
1	randomised trial	no serious limitations	no serious inconsistency	no serious indirectness	serious[2]	none	6/47 (12.8%)[3]	15/56 (26.8%)[4]	RR 0.48 (0.2 to 1.13)	139 fewer per 1000 (from 214 fewer to 35 more)	+++O MODERATE	CRITICAL

[1] Follow-up 6-8 weeks after surgery
[2] The 95% CI includes negligible effect, benefit and harm; small sample size
[3] Extra systemic warming
[4] Systemic warming

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

Figure 1 Summary estimates of association between extra systemic warming and standard systemic warming expressed as relative risk (RR) and 95% confidence interval (CI); outcome mortality.

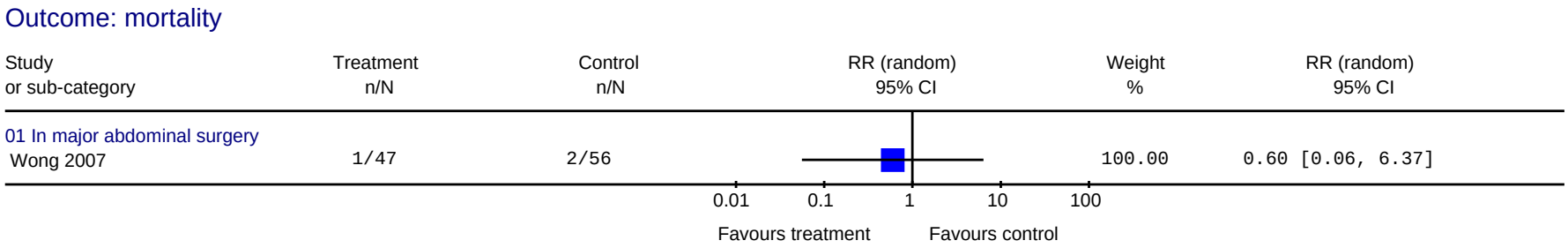
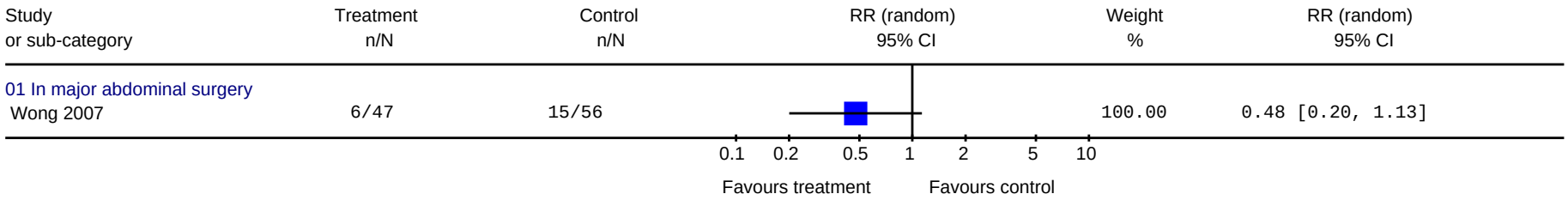


Figure 2 Summary estimates of association between extra systemic warming and standard systemic warming expressed as relative risk (RR) and 95% confidence interval (CI); outcome surgical site infection.



Comments

None.

Conclusion

There is low evidence that extra systemic warming compared to standard systemic warming reduces the rate of mortality in patients undergoing major open abdominal surgery. There is moderate evidence that extra systemic warming compared to standard systemic reduces the rate of SSI in patients undergoing open abdominal surgery. A single good quality trial compared this issue. All patients were systemically warmed by using a forced-air warming device during surgery. In the treatment group, patients were additionally warmed by using a conductive carbon polymer mattress two hours before and after surgery.

Reference list

1. Atkins D, Best D, Briss PA et al. Grading quality of evidence and strength of recommendations. *BMJ* 2004; **328**: 1490.
2. Wong PF, Kumar S, Bohra A, Whetter D, Leaper DJ. Randomized clinical trial of perioperative systemic warming in major elective abdominal surgery. *Br J Surg*. 2007 Apr;**94(4)**:421-6.