Transparent Polyurethane Film as an Intravenous Catheter Dressing

A Meta-analysis of the Infection Risks

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Objective.—To obtain a quantitative estimate of the impact on infectious complications of using transparent dressings with intravenous catheters.

Data Sources.—Meta-analysis of all studies published in the English literature, including abstracts, letters, and reports that examined the primary research question of infection risks associated with transparent compared with gauze dressings for use on central and peripheral venous catheters. Studies were identified by use of the MEDLINE database using the indexing terms *occlusive dressings*, *transparent dressings*, and *infection* and by review of referenced bibliographies.

Study Selection.—Seven of the 15 studies (47%) of central venous catheters and seven of 12 studies (58%) of peripheral catheters met our inclusion criteria for analysis. All studies used a prospective cohort design, utilized hospitalized patients, and reported at least one of our defined outcomes.

Extraction.—Data for each study were abstracted independently by three investigators. At least three studies were used in the analysis of each outcome.

Data Synthesis.—Applying a Mantel-Haenszel χ^2 analysis, use of transparent dressings on central venous catheters was significantly associated with an elevated relative risk (RR) of catheter tip infection (RR = 1.78; 95% confidence interval [CI], 1.38 to 2.30). Catheter-related sepsis (RR = 1.69; 95% CI, 0.97 to 2.95) and bacteremia (RR = 1.63; 95% CI, 0.76 to 3.47) were both associated with an elevated RR. Use of transparent dressings on peripheral catheters was associated with an elevated RR of catheter-tip infection (RR = 1.53; 95% CI, 1.18 to 1.99) but not phlebitis (RR = 1.02; 95% CI, 0.86 to 1.20), infiltration (RR = 1.12; 95% CI, 0.92 to 1.37), or skin colonization (RR = 0.99; 95% CI, 0.90 to 1.09).

Conclusion.—The results demonstrated a significantly increased risk of catheter-tip infection with the use of transparent compared with gauze dressings when used with either central or peripheral catheters. An increased risk of bacteremia and catheter sepsis associated with the use of transparent compared with gauze dressings for use on central venous catheters was suggested.

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MOST hospitalized patients receive peripheral infusion therapy via a peripheral venous catheter for administration of fluids and electrolytes, nutrition, and medications. Complications of peripheral

catheterization may include phlebitis, cellulitis, and sepsis. Factors associated with infection are placement for longer than 72 hours, plastic vs steel catheter, cutdown vs percutaneous placement, and skill of the venipuncturist.

Central venous catheters are increasingly used to allow hemodynamic monitoring, provide total parenteral nutrition, and administer medications that require instillation into a central vein. Once central venous catheters are inserted correctly, the major complication is infection.¹ Factors associated with an increased risk of central catheter infection include severity of underlying illness, multiple vs single lumen, use of catheter for total parenteral nutrition, and placement of the catheter in the

femoral site compared with jugular-subclavian placement.² Other risk factors include frequency of dressing changes, method of disinfection of skin prior to catheter insertion, use of antibacterial ointment at the insertion site, frequency of catheter replacement, and type of catheter dressing material.³

Transparent dressings made of a thin, semipermeable polyurethane material are widely used on central and peripheral venous catheters because they allow inspection of the insertion site and provide an occlusive dressing. Fourteen randomized prospective studies have assessed at least one infection outcome associated with use of transparent dressings on central⁴⁻¹⁰ or peripheral¹¹⁻¹⁷ venous catheters but have reported inconclusive results in part because of small numbers of patients. This meta-analysis was undertaken to give an overall quantitative assessment of risk of transparent dressings for use on central and peripheral venous catheters.^{18,19}

METHODS

Selection of Studies

We attempted to locate all research articles, abstracts, or letters published in the English language medical literature examining infectious complications associated with use of transparent dressings on venous catheters by scanning the MEDLINE Search Computer Retrieval Service from 1966 through the middle of 1991 using the key words *occlusive dressings* or *transparent dressings*, under the heading *wound infections*. All references cited in published works were investigated to detect additional studies. Data in abstract form were included in an attempt to avoid publication bias.²⁰ The existence of publication bias, whereby research with statistically significant results is more likely to be submitted and published than research with null or nonsignificant results, has been documented.²¹

We required a prospective randomized cohort design (or its equivalent) using hospitalized patients. An exception was

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Table 1.—Comparison of Studies Evaluating Transparent vs Gauze Dressings for Central Venous Catheters*

	Powell et al ⁴	Maki and Will ⁷	Powell et al ⁸	Maki and Will ¹⁰	Andersen et al ⁵	Young et al ⁹	Conly et al ⁶
Study design							
Cohort-prospective	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Random assignment to treatment group	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Study size							
No. of cases (TD)	123	225	262	93	60	132	42
No. of controls (GD)	138	148	111	105	75	36	34
Study method							
Ointment							
TD	None	None	None, povidone-iodine	None, povidone-iodine, neomycin sulfate	Nobecutan	None	None
GD	Povidone-iodine	None	Povidone-iodine	None, povidone-iodine, neomycin sulfate	Nobecutan	None	None
TD brand	Opsite	Tegaderm	Opsite	Opsite	Opsite	Opsite	Opsite
Duration, dressing changes							
TD	Every 7 d	Every 2 d, every 7 d	3 times/wk	Every 5 d	Indefinite	2 times/wk, every 7 d, every 10 d	Every 2 d
GD	3 times/wk	Every 2 d	3 times/wk, every 7 d	Every 2d	Indefinite	3 times/wk	Every 2 d
Duration of catheters, mean days							
TD	24	...	19.3-23.5	...	5.2	13.3-14.9	17.9
GD	22	...	20.3	...	5.4	13.1	13.5
Catheter location	Subclavian	Subclavian, jugular	Subclavian	Subclavian, arterial	Subclavian, antebrachial	Subclavian	Subclavian, jugular
Catheter use	TPN	Mixed†	TPN	Unknown	Unknown	TPN	TPN, chemotherapy
Results							
Catheter-tip-infection							
No. with outcome (%)							
TD	11/123 (8.9)	76/225 (33.8)	5/262 (1.9)	...	15/60 (25)	...	26/42 (61.9)
GD	4/138 (2.9)	37/148 (25)	2/111 (1.8)	...	5/75 (6.7)	...	8/34 (23.5)
RR	3.09	1.35	1.06	...	3.75	...	2.63
95% CI	1.01-9.44	0.97-1.89	0.21-5.38	...	1.45-9.73	...	1.37-5.04
P	.06	.08	.9	...	.003	...	.0001
Bacteremia							
No. with outcome (%)							
TD	...	...	15/262 (5.7)	...	3/60 (5)	12/132 (9.1)	...
GD	...	...	3/111 (2.7)	...	2/75 (2.7)	3/36 (8.3)	...
RR	...	...	2.12	...	1.88	1.09	...
95% CI	...	...	0.63-7.17	...	0.32-10.86	0.33-3.66	...
P	...	...	.2	...	.6	1.0	...
Catheter sepsis							
No. with outcome (%)							
TD	6/123 (4.9)	8/225 (3.6)	8/262 (3.1)	4/93 (4.3)	2/60 (3.3)	2/132 (1.5)	7/42 (16.7)
GD	1/138 (0.7)	5/148 (3.4)	5/111 (4.5)	2/105 (1.9)	1/75 (1.3)	1/36 (2.8)	0/34 (0)
RR	6.73	1.05	0.68	2.26	2.50	0.55	...
95% CI	0.82-55.14	0.35-3.16	0.23-2.03	0.42-12.05	0.23-26.91	0.05-5.85	...
P	.04	.9	.5	.3	.4	.6	.01

*TD indicates transparent dressings; GD, gauze dressings; TPN, total parenteral nutrition; RR, relative risk; and CI, confidence interval.

†Mixed indicates TPN, chemotherapy, and hemodynamic monitoring.

Young et al,⁹ who used different hospital floors with a similar patient population as evidenced by similar parameters (eg, age, sex, septicemia, and open septic drainage) as their mechanism of randomization. Kelsey and Gosling¹¹ used different dressing materials on patients admitted to the same medical units at different times. Case reports, editorials, and reviews that did not provide primary data were excluded. Eight studies of central venous catheters were excluded from analysis because the study was not prospective²² or comparative^{23,24}; allocation to treatment group was not randomized²⁵;

primary data were not provided¹²⁵⁻²⁷; outcome variables were not adequately defined^{24,25,27}; subcutaneously tunneled catheters were used²⁸; and paper tape was used for control dressing.²⁹ Five studies of peripheral venous catheters were excluded because the study was not prospective^{30,31} or comparative³²; allocation to treatment groups was not randomized^{30,33,34}; and primary data were not provided.^{30,34} Use of these rigid criteria allowed selection of a group of studies comparable with regard to the central research question, study design, and predictor and outcome measures.

Data Analysis

As outcome measures in each study were proportions (eg, the proportion of control subjects with catheter sepsis), a Mantel-Haenszel χ^2 analysis was performed. Risk ratios (ie, outcome rate in the transparent dressing group divided by the outcome rate in the control group) were calculated for each study, and the Breslow-Day statistic was used to assess their heterogeneity.³⁵ The Breslow-Day test may have relatively low power in this application, ie, only extreme departures from homogeneous risk ratios are likely to be flagged as statistically

significant. Under the assumption of homogeneous risk, the Mantel-Haenszel method was used to estimate a summary measure of effect, its confidence interval (CI), and to test its significance. Although this measure is most interpretable when the Breslow-Day test for interaction is nonsignificant, we also considered it if an interaction was present, but all individual studies demonstrated relative risks (RRs) greater than unity.³⁶ At least three studies were analyzed for each outcome.

Outcome Definitions

Data on complications were abstracted from studies that used central venous catheters (catheter-tip infection, bacteremia, and catheter sepsis) and peripheral venous catheters (phlebitis, infiltration, skin colonization, and catheter-tip infection). Data for each study were abstracted independently by three of us (K.K.H., D.J.W., and W.A.R.) using the defined outcome definitions. Catheter-tip infection was defined by a positive catheter-tip culture of greater than 15 colony-forming units using the method of Maki et al,³⁷ bacteremia by positive blood cultures drawn from a peripheral site or through a central line, and catheter sepsis by positive blood samples and catheter-tip cultures that yielded organisms of the same species. The two studies by Powell et al^{4,8} defined catheter-tip infection by the semiquantitative culture technique of Maki et al (C. Powell, RN, oral communication, February 28, 1991) and, hence, the data were included. Young et al⁹ did not use the semiquantitative technique (D. Russell, MD, oral communication, February 21, 1991) so their data were excluded.

RESULTS

Central Intravenous Catheters

All seven evaluable studies were published between 1982 and 1989; five were published in peer-reviewed journals,^{4,6,8,9} and two were abstracts^{7,10} (Table 1). Factors that varied among studies included location of the central venous catheter, clinical use of the catheter, regimen for dressing changes, patient population, and use and type of topical antiseptics. The arms of each study were comparable. Antiseptic ointment was used in four studies^{4,5,8,10}; in one study, it was used only under gauze dressings.⁴

Several studies reported a statistically significant higher infection risk with use of transparent dressings; three of five studies reported an increased risk of catheter-tip infection,^{4,6} zero of three an increased risk of bacteremia,^{5,8,9} and two of seven an increased risk of catheter sepsis^{4,6} (Table 1). However, an in-

Table 2.—Infection Risks of Transparent vs Gauze Dressings Used on Central Venous Catheters

Statistical Test	Catheter-Tip Infection	Bacteremia	Catheter Sepsis
Sample size			
Cases	712	454	937
Controls	506	222	647
Relative risk	1.78	1.63	1.69
95% confidence interval	1.38-2.30	0.76-3.47	0.97-2.95
P	<.001	.2	.06
Interaction	.075	.745	.106

creased RR was shown for all outcomes of catheter-tip infection (RR of 1.06 to 3.75) and bacteremia (RR of 1.09 to 2.12). In no case did a study report a significantly increased risk of infection associated with gauze dressings.

Combining these studies yielded more than 1200 subjects for the evaluation of catheter-tip infection and catheter sepsis and more than 650 subjects for the evaluation of bacteremia. Study results were generally comparable: the point estimate of the RR exceeded unity for all catheter-tip and bacteremia studies, and the Breslow-Day test indicated relative homogeneity among outcome measures ($P > .05$). The statistically significant RR for catheter-tip infection was 1.78 (95% CI, 1.38 to 2.30; $P < .001$), and catheter sepsis approached statistical significance (RR = 1.69; 95% CI, 0.97 to 2.95; $P = .06$). The RR for bacteremia was of the same order of magnitude (RR = 1.63; 95% CI, 0.76 to 3.47; $P = .2$) but was not statistically significant (Table 2).

Peripheral Venous Catheters

The seven evaluable studies were published between 1984 and 1989; six were published in peer-reviewed journals,^{11,12,14-17} and one appeared as an abstract.¹³ Factors that varied among the studies included type of transparent dressing, insertion personnel, use and type of antibacterial ointment, and duration of transparent and gauze dressings. Five brands of transparent dressing materials were used (Table 3). Antibacterial iodophor was used in one study, only under the gauze dressing.¹² In all studies, transparent dressings remained in place for the lifetime of the catheter, and gauze dressings were routinely changed in all but two studies.^{11,15} Catheters were replaced routinely in all studies at 48 to 72 hours, except for one in which 23% of the catheters remained in place for 72 hours or longer.¹⁵

The likelihood of catheter-tip infection was determined in four studies^{13-15,17} (Table 3). Only one study showed a significant risk associated with the use of transparent dressings.¹³ However, all studies showed a positive RR, which varied between 1.23 and 4.09.

The risks of phlebitis and infiltration

were assessed in five studies^{11,12,15-17} and the risk of skin colonization in three.^{14,15,17} No study demonstrated a statistically significant risk, except for one that reported a high risk of phlebitis in patients with gauze dressings.¹²

Combining these seven studies that met our inclusion criteria yielded over 1800 subjects for all outcome measures (Table 4). A consistent risk (interaction term, $P > .05$) was demonstrated for catheter-tip infection, with an RR of 1.53 (95% CI, 1.18 to 1.99; $P = .002$). No significant overall effect was demonstrated between transparent and gauze dressings for phlebitis, infiltration, and skin colonization. Point estimates of the RR were on both sides of unity, even to the point of a statistically significant interaction for phlebitis.

COMMENT

Determining the risk factors associated with catheter-related sepsis is an important step in minimizing nosocomial bacteremia since bacteremia results in significant morbidity and increased costs.³⁸ The RRs calculated by our meta-analysis represent the best estimates of the additional infection risks associated with the use of transparent compared with gauze dressings. For central venous catheters, all three outcome measures demonstrated RRs between 1.63 and 1.78. For catheter-tip infection, the RR of 1.78 was statistically significant ($P < .001$). For bacteremia (RR = 1.63; $P = .2$) and catheter-related sepsis (RR = 1.69; $P = .06$), the results did not reach statistical significance, but the trend suggests that transparent dressings adversely effect the risk of infection. Our data suggest that use of transparent dressings leads to an increased risk of bacteremia and sepsis. First, it has been well described in the literature that catheter-tip infection is an excellent harbinger of bacteremia and sepsis.³⁸ Second, for central venous catheters, the RRs determined in the meta-analysis for catheter-tip infection, bacteremia, and catheter-related sepsis were consistent in demonstrating an increased risk with the use of transparent dressings, with a range of 63% to 78%.

For peripheral venous catheters, the

Table 3.—Comparison of Studies Evaluating Transparent vs Gauze Dressings for Peripheral Venous Catheters*

	Nicola and DeChairo ¹²	Kelsey and Gosling ¹¹	Joseph and Marzouk ¹³	Craven et al ¹⁴	Maki and Ringer ¹⁵	Littenberg and Thompson ¹⁶	Hoffmann et al ¹⁷
Study design							
Cohort-prospective	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Random assignment to treatment group	Yes	No	Yes	Yes	Yes	Yes	Yes
Study size							
No. of cases (TD)	148	369	152	316	1025	202	300
No. of controls (GD)	136	292	207	421	1063	99	298
Study method							
Ointment							
TD	None	None	None	None	Iodophor†	None	None
GD	Iodophor	None	None	None	None	None	None
TD brand	Opsite	Opsite	Ensure	Opsite	Tegaderm	Uniflex, Tegaderm	Bioclusive
Duration, dressing changes							
TD	Indefinite	Indefinite	Indefinite	Indefinite	Indefinite	Indefinite	Indefinite
GD	Every 1 d	Indefinite	Not stated	Every 1 d	Indefinite, every 2 d	Every 1 d	Every 1 d
Duration of catheters, mean							
TD	Every 3 d	2.6 d	Every 3 d	Every 2 d	52 h, 52 h	39 h, 32 h	Every 2-3 d
GD	Every 3 d	2.6 d	Every 3 d	Every 2 d	54 h, 55 h	47 h	Every 2-3 d
Insertion team	IV team	Staff	IV team	IV team	Staff	IV team	IV team
Outcome evaluators	IV team	Researchers	Staff	IV team	Researchers	IV team, staff	Researchers
Results							
Catheter-tip infection							
No. with outcome (%)							
TD	...	...	21/152 (13.8)	28/316 (8.9)	58/1025 (5.7)	...	14/246 (5.7)
GD	...	...	7/207 (3.4)	24/421 (5.7)	49/1063 (4.6)	...	10/224 (4.4)
RR	...	...	4.09	1.55	1.23	...	1.39
95% CI	...	...	1.78-9.36	0.92-2.63	0.85-1.78	...	0.63-3.07
P	...	...	<.001	.1	.3	...	.4
Phlebitis							
No. with outcome (%)							
TD	78/255 (30.6)	50/369 (13.5)	...	...	97/1025 (9.5)	33/202 (16.3)	24/246 (9.8)
GD	58/270 (21.5)	29/292 (9.9)	...	...	100/1063 (9.4)	8/99 (8)	17/224 (7.6)
RR	0.70	1.36	...	...	1.01	2.02	1.29
95% CI	0.53-0.94	0.89-2.10	...	...	0.77-1.31	0.97-4.21	0.71-2.33
P	.02	.2	...	...	1.0	.05	.4
Infiltration							
No. with outcome							
TD	46/270 (17.0)	23/369 (6.2)	...	...	69/1025 (6.7)	52/202 (25.7)	12/300 (4)
GD	32/255 (12.5)	24/292 (8.2)	...	...	68/1063 (6.4)	17/99 (17.2)	13/298 (4.5)
RR	1.36	0.758	...	...	1.05	1.50	0.92
95% CI	0.90-2.06	0.44-1.31	...	...	0.76-1.46	0.93-2.42	0.43-1.98
P	.1	.3	...	...	.8	.1	.8
Skin colonization							
No. with outcome							
TD	...	...	...	34/217 (15.7)	427/1025 (41.7)	...	53/246 (21.5)
GD	...	...	...	37/286 (12.9)	470/1063 (44.2)	...	39/224 (17.4)
RR	...	...	...	1.21	0.94	...	1.35
95% CI	...	...	...	0.79-1.86	0.85-1.04	...	0.93-1.96
P	...	...	...	.4	.2	...	.1

*TD indicates transparent dressings; GD, gauze dressings; IV, intravenous; RR, relative risk; and CI, confidence interval.

†Refers to iodophor impregnated transparent dressing.

meta-analysis demonstrated a 53% increased risk of catheter-tip infection associated with the use of transparent dressings. It has been demonstrated that in most cases, bacterial contamination of peripheral venous catheters results from colonization of the outer surface of the catheter by cutaneous flora. Catheter colonization may then lead to bacteremia or septic thrombophlebitis. While it should not be assumed that transparent dress

Table 4.—Infection Risks of Transparent vs Gauze Dressings Used on Peripheral Venous Catheters

Statistical Test	Catheter-Tip Infection	Phlebitis	Infiltration	Skin Colonization
Sample size				
Cases	1739	2112	2166	1488
Controls	1935	1933	2007	1593
Relative risk	1.53	1.02	1.12	0.99
95% confidence interval	1.18-1.99	0.86-1.20	0.92-1.37	0.90-1.09
P	.002	.8	.3	.8
Interaction	.056	.02	.301	.102

ings would be associated with a 53% increase in bacteremia, it is likely that higher rates of catheter-tip infection will result in an elevated rate of bacteremia. The noninfectious complications of phlebitis and infiltration were similar regardless of the dressing material used.

The mechanism by which transparent dressings increase catheter-associated infection is likely the promotion of bacterial growth,³⁹ which may be related to the inadequate moisture vapor permeability.¹⁴ For example, Maki and Will⁷ reported that the mean log of bacteria under dressings (ie, colonization of skin) was significantly greater under transparent dressings left for 2 and 7 days ($P < .01$) compared with gauze dressings changed every 2 days.⁷

Several covariates that may affect the infection risks associated with venous catheterization including the duration of catheter use, frequency of dressing changes, and use of antiseptic ointment, are potential confounders in the meta-analysis. In all studies, duration of catheter use was similar for both dressing groups, eliminating this covariate as an explanation for our results. In several studies, gauze dressings were changed more frequently than transparent ones. Changing transparent dressings more frequently would significantly increase the cost of maintaining an intravenous line since the cost associated with transparent dressings is approximately three times that of gauze dressings,¹⁷ and the preparation and dressing time are approximately the same, averaging somewhat less than 4 minutes.⁷ Similarly, the results of the meta-analysis may have been confounded by the differential use of topical antibacterial agents. Although topical antiseptic ointments were used more often with gauze than transparent dressings, the preferential use was small compared with the total number of patients studied. Further, the use of antibacterial ointment on transparent dressings may impair the ability of this material to adhere to skin, and it obscures the entry site, thereby negating two potential advantages for the use of transparent dressings.

In a study of 865 catheters, Richet et al⁴⁰ analyzed several risk factors for infection, including site of insertion, type of dressing, antiseptic use, duration of catheterization, and purpose of cannula. A logistic regression analysis revealed that catheter-tip infection was independently associated with use of transparent dressings, duration of catheterization, and jugular insertion site.⁴⁰

Based on our data, we suggest that the increased infection risks associated with transparent dressings be considered in institutional decisions regarding their use

until a large, well-controlled study demonstrates similar infection risks between gauze and transparent dressings. New, more permeable dressings may result in reducing the infection risks associated with this type of dressing.

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