Computer simulation model of the economics of a reusable fabric technology warming blanket compared to a disposable forced air warming blanket

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Introduction

Maintaining normothermia in surgical patients avoids certain complications and is being considered as a measure of anesthesia quality by national bodies like Medicare. Various modalities can be employed to warm patients including forced air warming (FAW) with disposable blankets. A recently developed warming system (HotDog, Augustine Biomedical, Eden Prairie, MN) uses a different technology; an electric current heats a reusable resistive polymer blanket covered by a polypropylene sheet.1 The aim of this computer simulation study was to evaluate the economics of such a reusable warming blanket compared to FAW disposable blankets, assuming clinical efficacy for both is equivalent.

Figure 1
Reusable Warming Blanket

Figure 2
Disposable FAW

Table 1
Cost Assumptions

Pre, Intra and Post Warming Expense Item	Reusable Hourly Rate	Reusable Per Use	Disposable FAW Hourly Rate	Disposable FAW Per Use
Blanket: pre-warming		$ 2.73		$ 12.00
Blanket: intra-operative		$ 2.25		$ 8.00
Blanket: post-warming		$ 1.29		$ 7.00
Electrical energy consumption	$ 0.08		$ 0.11	
PACU nurse salary & benefits	$ 40.64			
Pre warming nurse salary & benefits	$ 40.64			
OR nurse salary & benefits	$ 40.64			
SOPCU nurse salary & benefits	$ 40.64		$ 40.64	
Nursing Assistant salary & benefits	$ 20.20			
Cotten blankets pre-warming laundry costs (1)		$ 1.08		$ 1.08
Cotten blanket post warming laundry (2)	$ -	$ 2.16		$ 2.16

Reordering and Waste Disposal Items	Hourly Rate	Per Use
Materials Management salary & benefits	$ 20.03	
Custodian salary & benefits	$ 18.07	
Waste disposal service cost/pound		$ 0.05
Accounts payable clerk salary & benefits	$ 24.84	

Methods

The baseline analysis assumed a hospital with 28 combined preanesthesia/Phase 2 recovery rooms, 14 ORs, and 16 Phase 1 PACU beds. The cost model for the FAW disposable blanket (acquisition cost=$12 for preop, $7 for intraop, 7$ postop) assumed 58 blower units (one for each pre, intra and postop location + 2 replacements) at no additional acquisition cost to hospital. The cost model for the reusable blanket product assumed a hospital acquisition cost of $1,249 for each preop/Phase 2 location, $1,449 for each OR, $1,599 for each PACU bed, 5 replacements, and a maintenance contract at $23,188/year. Labor costs were also included: nurse ($41/hr), OR assistant ($20/hr), materials management ($20/hr), custodian ($18/hr), and accounts payable clerk ($25/hr). Patient time in preop was assumed to be 109 mins (SD 22), intraop=75 mins (SD=54), and PACU=60 min (SD 18). Using these variables a Markov chain Monte Carlo simulation model (Arena, Rockwell Automation) was constructed and run using either disposable or reusable warming blankets to meet the existing needs of the surgical suite. Sensitivity analysis revealed key parameters.

Table 2
Time Distributions

Description	Distribution	Time Unit	Minimum	Average	Maximum
01 Patient warmed by HD blanket in pre surgical area	Triangular	Hours	0.5	1	1.5
01 Patient warmed by FAW blanket in presurgical area	Triangular	Hours	0.5	1	1.5
03 Tech cleans HD blanket in pre warming	Triangular	Minutes	0.5	1	1.5
04 Nurse warms blankets in SOPCU HD group	Triangular	Minutes	0.5	1	1.5
04 Nurse warms blanket in SOPCU for FAW group	Triangular	Minutes	0.5	1	1.5
05 HD pts warmed by cotten blankets presurgical area	Constant	Minutes	0.5	1	1.5
05 FAW pts warmed by cotten blankets presurgical area	Constant	Minutes	0.5	1	1.5
07 Patient warmed by HD blanket intra operatively	Lognormal	Minutes	5	74.8	622
07 Patient warmed by FAW blanket intra operatively	Lognormal	Minutes	5	74.8	622
08 Tech cleans HD blanket in OR	Triangular	Minutes	0.5	1	1.5
10 Patient warmed post operatively with HD blanket	Triangular	Hours	0.5	1	1.5
10 Patient warmed by FAW post operatively	Triangular	Hours	0.5	1	1.5
11 Patient expensed for HD blanket post operatively	Constant	Minutes	0.5	1	1.5
11 Patient expensed for FAW blanket use post operative	Constant	Minutes	0.5	1	1.5
12 Tech cleans HD blanket	Triangular	Minutes	0.5	1	1.5
13 Nurse warms blanket in PACU HD group	Triangular	Minutes	0.5	1	1.5
13 Nurse warms blanket in PACU for FAW group	Triangular	Minutes	0.5	1	1.5
14 HD patients warmed by cotten blankets post operative	Constant	Minutes	0.5	1	1.5
14 FAW patients warmed post operatively with cotten blankets	Constant	Minutes	0.5	1	1.5
15 Custodian bags FAW disposables at end of day	Constant	Minutes	0.5	0	1.5
16 Custodian removes and transports waste	Triangular	Minutes	5	10	15
17 FAW blanket reordering process	Triangular	Minutes	2	5	10
18 FAW recieving process	Triangular	Minutes	5	10	15
19 Accounts payable pays monthly bill for FAW blankets	Triangular	Minutes	1	5	10

Results

For the baseline case hospital, at an annual case volume of 6000 (approximately 1.71 cases/OR/day for 250 working days/yr) with 20% blanket utilization pre-operatively, 70% intra-operatively and 35% post-operatively the per use costs of reusable ($13.89, +/- .10) and disposable ($13.76, +/- .21) blankets are not significantly different (p <0 .001). As case volumes/yr increased above 6000, or patient use stayed above a combined average of 41% in each area, the per patient warming costs favored reusable blankets compared to disposable blankets. At the specific hospital studied, for its 9,332 total cases, the predicted per patient cost for disposable blankets equaled $13.79, +/- .18 and reusable was $9.94, +/- .23 (p<0.001).

Figure 3
Virtual Experiment

Discussion

The economics of a reusable warming blanket hinge on the number of cases performed in the surgical suite, and how frequently blankets are used in the preop, intraop, and PACU segments. As the number of surgical cases increases, or the use rate increases, the fixed cost of reusable warming technology is spread among more cases.

Table 3
Scenario Analysis

Scenario	Annual Cases	Combined pre-anesthesia & Phase 2 Recovery	Number of Warming Units Intra-operative	Post-operative	Disposable FAW FAW total costs	Reusable With 1 replacement warming unit per 2000 cases per year	Cost Difference: FAW & Reusable	Total annual cost savings
Large	20,000	28	14	16	24.536	7.85	16.686	$ 333,720
Midsize	10,000	28	14	16	24.617	9.33	15.287	$ 152,870
Midsize	6000	28	14	16	24.939	11.245	13.694	$ 82,164
Midsize	6000	28	14	7	10	24.939	8.94	15.999	$ 95,994
Small	3000	10	4	8	24.687	10.00	14.69	$ 44,061

Assumes 20% blanket utilization pre-operatively, 70% intra-operatively and 35% post-operatively