

Bayesian Belief Network Model of the Radical Prostatectomy Pathway

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Outline

- Clinical Pathway and Radical Prostatectomy Pathway (RPP)
 - Bayesian Belief Network (BBN)
 - BBN Model for RPP
 - Mobile Pathway Monitor (MPM)
 - Discussion
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Clinical Pathway

- ❑ Operationalizes best practices and represents sequencing and timing of interventions by clinicians for a particular clinical presentation.
- ❑ Designed to minimize delays, improve resource utilizations and enhance the quality of tertiary care.
- ❑ Used to monitor and control patient's progress measured according to standard process and clinical outcomes, e.g., length of stay (*LOS*).

Radical prostatectomy pathway (RPP) describes patient's management (activities, outcomes, variance record) from a post-op to a fourth day of stay in the hospital.



Patient Day # Date	CRITICAL PATH									
	Pre-Admit Unit	Same Day Admit	OR Day (PACU)	Post-op Day 1	Post-op Day 2	Post-op Day 3	Post-op Day 4	Clinic Visit #1	Clinic Visit #2	
Consults	<ul style="list-style-type: none"> • Anaesthesia • PAU assessment 			<ul style="list-style-type: none"> • Home Care 						
Medications	<ul style="list-style-type: none"> • Review patient medications 	<ul style="list-style-type: none"> • Heparin in SB • po-IV medications as ordered • If NPO at 50 cc/hrs for all patients where IV medications are ordered 	<ul style="list-style-type: none"> • Patient specific medications • Analgesic Intrathecal Protocol • If as ordered • Oxygen Titration Protocol • i.v. Heparin 5000 units at 2h • NSMD as ordered 	<ul style="list-style-type: none"> • Patient specific medications • Analgesic Intrathecal Protocol • If as ordered • Oxygen Titration Protocol • i.v. Heparin 5000 units at 2h • NSMD as ordered 	<ul style="list-style-type: none"> • Patient specific medications • Analgesic Intrathecal Protocol • DC/TZ titrating well • Oxygen Titration Protocol • i.v. Heparin 5000 units at 2h • NSMD as ordered 	<ul style="list-style-type: none"> • Patient specific medications • Analgesic Intrathecal Protocol • DC Heparin 	<ul style="list-style-type: none"> • Patient specific medications • Analgesic Intrathecal Protocol 			
Tests	<ul style="list-style-type: none"> • Type & screen • CBC • Na, K, Cl, glucose, creatinine • Chest x-ray • ECG • Urine R & M • C & S • Haptoglobin • urine cell • E proteins as Correlate • ANP/NT 	<ul style="list-style-type: none"> • Patients with chest, renal failure • Sodium, potassium, chloride • or urine • Haptoglobin • E proteins as Correlate • ANP/NT • E proteins as Correlate • ANP/NT 	<ul style="list-style-type: none"> • CBC 1 year post-op 			<ul style="list-style-type: none"> • CBC • Na, K, Cl, creatinine 				
Assessments/Treatments	<ul style="list-style-type: none"> • Vital signs • Monitor for TED stockings • Patient/caregiver specific assessment 	<ul style="list-style-type: none"> • Vital signs • SpO₂ • Apply TED stockings • Complete pre-op checklist 	<ul style="list-style-type: none"> • VS q4h • I&O q4h • SpO₂ q4h • TED stockings • Monitor dressing, change if soiling • Inspecting urethral catheter • Jackson Post • System assessment • respiratory: O₂, Et CO₂ & pin • Jackson Post 	<ul style="list-style-type: none"> • VS q4h • I&O q4h • SpO₂ q4h • TED stockings • Monitor dressing, change if soiling • Inspecting urethral catheter • System assessment • respiratory: O₂, Et CO₂ & pin • Jackson Post 	<ul style="list-style-type: none"> • VS q4h • I&O q4h • SpO₂ q4h • TED stockings • Remove dressing – open to air • Inspecting urethral catheter • System assessment • respiratory: O₂, Et CO₂ & pin • Jackson Post 	<ul style="list-style-type: none"> • VS • Monitor incision • Inspecting urethral catheter output • Remove dressing over drain site • open to air • Home with clips 	<ul style="list-style-type: none"> • Remove clips • Assess wound, pack with saline soaked gauze if applicable 	<ul style="list-style-type: none"> • Remove urethral catheter • Assess wound, wound care as indicated 		
Activity	<ul style="list-style-type: none"> • AAT 	<ul style="list-style-type: none"> • AAT 	<ul style="list-style-type: none"> • Bed rest • Deepse = 1 	<ul style="list-style-type: none"> • Chair = 3 • Ambulate for short walk 	<ul style="list-style-type: none"> • Progressive ambulation with minimal assistance 	<ul style="list-style-type: none"> • AAT independent 	<ul style="list-style-type: none"> • AAT 	<ul style="list-style-type: none"> • AAT 	<ul style="list-style-type: none"> • AAT 	
Nutrition/ Elimination		<ul style="list-style-type: none"> • NPO from 2400 hours 	<ul style="list-style-type: none"> • NPO 	<ul style="list-style-type: none"> • Sip clear fluids 	<ul style="list-style-type: none"> • Full fluids to D&T 	<ul style="list-style-type: none"> • D&T 	<ul style="list-style-type: none"> • D&T • Assess bowel function • Assess urine output (colour, consistency) 	<ul style="list-style-type: none"> • D&T • Assess bowel function • Assess urine output (colour, consistency) 		
Patient Teaching	<ul style="list-style-type: none"> • Provide Radical Prostatectomy Teaching Manual • Patient specific medications for monitoring of surgery • Pre-op preparations: <ul style="list-style-type: none"> - Urinary based prep day before surgery - Navel cleanse 	<ul style="list-style-type: none"> • Reinforce pre-surgery teaching • Care of patient belongings 	<ul style="list-style-type: none"> • Reinforce <ul style="list-style-type: none"> - deep breathing & coughing - leg exercises - wound care - activity - pain management - diet - incision care 	<ul style="list-style-type: none"> • Reinforce <ul style="list-style-type: none"> - deep breathing & coughing - wound care - activity - pain management - diet - incision care 	<ul style="list-style-type: none"> • Reinforce <ul style="list-style-type: none"> - activity - diet • Review <ul style="list-style-type: none"> - catheter care & drainage system 	<ul style="list-style-type: none"> • Review discharge instructions: <ul style="list-style-type: none"> - activity - pain management - wound care - catheter care and drainage system 	<ul style="list-style-type: none"> • Reinforce discharge instructions 	<ul style="list-style-type: none"> • Reinforce <ul style="list-style-type: none"> - catheter care and drainage system - wound care • Discuss catheter care 	<ul style="list-style-type: none"> • Reinforce <ul style="list-style-type: none"> - catheter care - wound care - activity - diet - incision care • Refer to Pre-Discharge Support Group 	
Discharge Planning	<ul style="list-style-type: none"> • Discuss Care Map and expected length of stay • Initiate Surgical Portable Discharge Assessment & Planning Care Map 				<ul style="list-style-type: none"> • Complete Surgical Portable Discharge Assessment & Planning Care Map 	<ul style="list-style-type: none"> • Confirm discharge plans with patient/family • Pre-discharge written pre • Follow-up appointment within 2 days at hospital's best clinic 	<ul style="list-style-type: none"> • Complete Discharge Summary section of Surgical Portable Discharge Assessment & Planning Care Map 	<ul style="list-style-type: none"> • Modify Home Care referral if applicable • Follow-up appointment in one week at urologist's clinic 	<ul style="list-style-type: none"> • Refer to Pre-Discharge Support Group 	
Patient progress corresponds with Care Map	<p>Nursing</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p>	<p>Nursing</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p>	<p>Nursing</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p>	<p>Nursing</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p>	<p>Nursing</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p>	<p>Nursing</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p>	<p>Nursing</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p>	<p>Nursing</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p>	<p>Nursing</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p>	<p>Nursing</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No _____ N</p>

Bayesian Belief Network (BBN)

- Models a stochastic process composed of the events with associated conditional probabilities and relationships between these events.
 - Generates an answer to conditional-type queries, e.g., *considering the patient's health status on a given day, what impact would "x" have on meeting the expected day of discharge.*
 - Used to predict the impact of observed outcomes and activities on the *LOS* on the basis of current observations recorded in the pathway.
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Variables in the RPP (1)

Code	Name	Values	Descriptions or examples	Post-op day		
				1	2	3
Psycho	Patient psychological condition	abnormal	e.g. Patient's anxiety;	+		
		normal	Patient can understand and is compliant	+		
Vs	Vital signs	abnormal	e.g. The pulse rate of the patient is abnormal	+	+	+
		normal	Vital signs of the patient are normal	+	+	+
Temp	Temperature	abnormal	Patient's temperature is abnormal		+	+
		normal	Patient's temperature is normal		+	+
ActW	Activity with the RPP	no	Patient does not ambulate	+	+	+
		ambulate	Patient does (progressive) ambulation	+	+	+
NutriW	Nutrition with the RPP	fluid	Patient drinks fluid	+	+	+
		regular	Patient has regular foods		+	+
NutriO	Nutrition outcome	vomit	Patient vomits	+	+	+
		nausea	Patient feels nausea	+	+	+
		normal	None of the above	+	+	+
PainR	Pain at rest	medium	The verbal pain score at rest of the patient is between 4-7	+	+	+
		mild	The verbal pain score at rest of the patient is between 1-3	+	+	+
		nopain	Patient has no pain at rest	+	+	+
Resp	Respiratory function	mild	e.g. Crackle, difficult to breath	+		
		normal	The respiratory function of the patient is normal	+	+	+

Variables in the RPP (2)

Code	Name	Values	Descriptions or examples	Post-op day		
				1	2	3
Jp	JP output	large	The amount of JP is large	+	+	+
		medium	The amount of JP is medium	+	+	+
		small	The amount of JP is small	+	+	+
		d/c	JP is discontinued		+	+
Hema	Evidence of hematuria	yes	Patient has evidence of hematuria	+	+	+
		bt	Patient has blood-tinged	+	+	+
		no	Patient has no evidence of hematuria	+	+	+
UrineO	Urine output	inadequate	The amount of urine is inadequate	+	+	+
		adequate	The amount of urine is adequate	+	+	+
BowelS	Bowel sounds outcome	absent	The bowel sound is absent	+	+	
		present	The bowel sound is present	+	+	
PainM	Mobility outcome	medium	The verbal pain score with mobility of the patient is between 4-7	+	+	+
		mild	The verbal pain score with mobility of the patient is between 1-3	+	+	+
		nopain	Patient has no pain with mobility	+	+	+
Wound	Wound outcome	medium	Patient's incision has severe infection		+	+
		mild	Patient's incision has mild infection		+	+
		normal	Patient's incision has no evidence of redness, swelling, rash, dehiscence		+	+
LOS	Length of patient stay	delayed	Patient is discharged after Post-op day 3			
		met	Patient is discharged on or before Post-op day 3 (LOS is 4 days or shorter)			

Developing BBN Model for the RPP

□ Learning data set:

- Charts and pathways of 75 patients managed by various clinical teams between 2002 and 2003 at The Ottawa Hospital – Civic Campus.
- Data transcribed from patient's records and evaluated by urology specialists for consistency and correctness.

□ Learning method:

- K2 algorithm used to develop the BBN structure and calculate the conditional probabilities from data.

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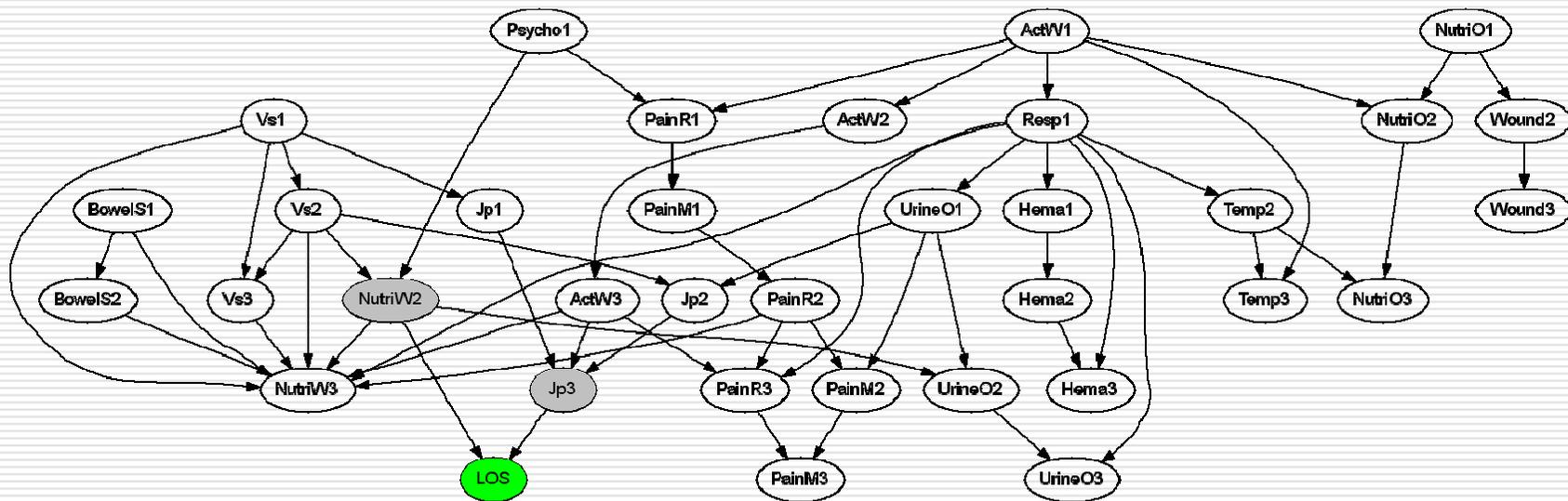
Slide 8

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I would remove the reference to Bayesware Discoverer. K2 seems to be a well-known "generic" algorithm.

Szymon Wilk, 27/12/2005

Structure of the BBN Model for the RPP



Verification of the BBN Model for the RPP

□ Testing data set:

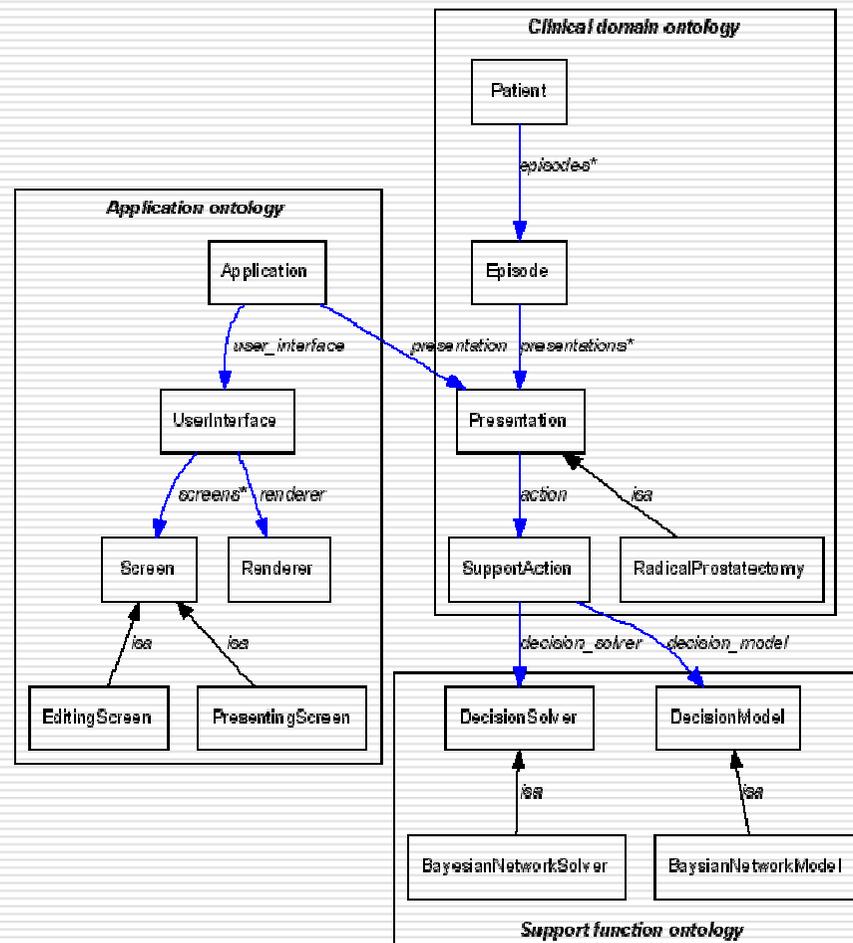
- Charts and pathways of 50 patients managed by various clinical teams between 2002 and 2003 at The Ottawa Hospital – Civic Campus.
- Independent from the learning set.
- Data reviewed according to the same regimen as learning data set.

□ Test results:

Accuracy	BBN	Decision tree	Logistic regression
<i>Met LOS</i>	90.9%	90.9%	93.9%
<i>Delayed LOS</i>	64.7%	41.2%	41.2%
Overall	82.0%	74.0%	76.0%

BBN RPP Mobile Pathway Monitor

- MPM implementation in *MET* environment using ontologies



MET-MPM Interface

Desktop computer

Application: **Wilk, Szymon** RadicalProstatectomy

Day 1

- Activity with the RPC: Ambulate No
- Bowel sounds: Absent Present
- Evidence of hematuria: Blood-tinged No Yes
- JP output: Discontinued Large Medium Small
- Nutrition outcome: Nausea Normal Vomit
- Pain at rest: Medium Mild None
- Pain with mobility: Medium Mild None
- Psychological condition: Abnormal Normal
- Respiratory function: Mild Normal
- Urine output: Adequate Inadequate
- Vital signs: Abnormal Normal

Day 2

- Activity with the RPC: Ambulate No
- Bowel sounds: Absent Present
- Evidence of hematuria: Blood-tinged No Yes
- JP output: Discontinued Large Medium Small
- Nutrition outcome: Nausea Normal Vomit
- Nutrition with the RPC: Fluid Regular
- Pain at rest: Medium Mild None
- Pain with mobility: Medium Mild None
- Temperature: Abnormal Normal
- Urine output: Adequate Inadequate
- Vital signs: Abnormal Normal
- Wound outcome: Medium Mild Normal

Day 3

- Activity with the RPC: Ambulate No
- Evidence of hematuria: Blood-tinged No Yes
- JP output: Discontinued Large Medium Small
- Nutrition outcome: Nausea Normal Vomit
- Nutrition with the RPC: Fluid Regular
- Pain at rest: Medium Mild None
- Pain with mobility: Medium Mild None
- Temperature: Abnormal Normal
- Urine output: Adequate Inadequate
- Vital signs: Abnormal Normal
- Wound outcome: Medium Mild Normal

Patients list Synchronize

Handheld computer

Application: **Wilk, Szymon** RadicalProstatectomy

Day 1 Day 2 Day 3

- Nutrition outcome: Nausea
- Pain at rest: None
- JP output: Small
- Evidence of hematuria: Adequate Inadequate
- Urine output: Inadequate
- Bowel sounds: Ok
- Pain with mobility: None
- Wound outcome: Normal
- Temperature: (no value)

Patients list Synchronize

Discussion

- ❑ BBN models the RPP and very well describes probabilistic inferences.
 - ❑ The use of a BBN model facilitates identification of the events directly associated with the *LOS*.
 - ❑ Revising the conditional probabilities of the variables provides information that can be used in re-evaluating a patient's management.
 - ❑ MPM implementation can be used to provide new insight into patient's clinical condition given current observation.
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A Challenge

Health care is one of the slowest IT-adopting industries It is like Detroit putting out futuristic hydrogen cars but using paper processing and manual labor for manufacturing

Jeff Miller, Hewlett-Packard

Thank You

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