

Web-based Clinical Pathway for Reducing Practice Variations in Radical Prostatectomy

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Background: A clinical pathway support system on the Internet (CPSSI) has been designed for creating and implementing a web-based clinical pathway for radical prostatectomy. This investigation assessed the effects of the web-based clinical pathway for radical prostatectomy on practice variations.

Methods: From June 2002 to Jun 2003, 22 consecutive patients with localized prostate cancer who underwent radical prostatectomy were treated according to the web-based clinical pathway. The treatment results were compared with an identically sized sample of patients treated during the year before implementing the web-based clinical pathway. Variations before and following the implementation of the web-based clinical pathway for radical prostatectomy were also assessed. The CPSSI automatically measured pathway variations and length of hospital stay.

Results: After implementing the web-based clinical pathway, the average hospital stay was reduced significantly ($p = 0.0001$). The mean number of variations also differed markedly ($p = 0.0002$).

Conclusion: This study concludes that the CPSSI-based clinical pathway support system may provide a good tool for creating and implementing a web-based clinical pathway. After implementing the web-based clinical pathway for radical prostatectomy, practice variations and length of stay were reduced considerably. Moreover, automatically assessing the effects of web-based clinical pathway implementation can enhance the quality of patient care.
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Key words: web-based, clinical pathway, decision support system, health outcome

The web is used as a tool to communicate information among physicians, nurses and patients.⁽¹⁾ Recent studies have reported good results for web-based surveys, clinical monitoring systems, and distance medical education programs.⁽²⁻⁴⁾ In clinical process management, implementation of web-based clinical pathways has been reported to exhibit good

results that are more accurate than paper-based pathways in detecting variances.⁽⁵⁾

The implementation of clinical pathways has been used to monitor health outcomes and also to improve the quality of patient care.^(6,7) Physicians, administrators and nurses, as well as patients and their families, have all contributed to formulating

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and implementing clinical pathways to optimize medical care. Pathways for standardizing numerous aspects of patient care have been shown to reduce variation and the cost of medicine, and to reduce morbidity and mortality in critically ill patients.⁽⁸⁾ Reduction in variations in therapy provision by physicians and organizations may lead to reduced use of certain high-risk procedures with limited benefits, thus reducing the need for critical care services.⁽⁹⁾ The main objective in clinical pathway implementation is to reduce unnecessary practice variations, enhance the quality of care, and improve patient outcomes.

This investigation assessed the effects of a web-based clinical pathway for radical prostatectomy on practice variations. This study analyzed the variations in treatment policies before and after implementation of the web-based pathway.

Our institution first established its clinical pathway development team (CPDT) in 1995. Since 1997 the CPDT has developed and formalized numerous clinical pathways for urological surgery.⁽¹⁰⁾ In July 2000, a web-based clinical pathway for radical nephrectomy was implemented and it improved health outcomes as much as a paper-based pathway.⁽⁵⁾ Furthermore, in January 2002 a clinical pathway support system on the internet (CPSSI) was established to permit users to create and implement their own web-based clinical pathways (Fig. 1).

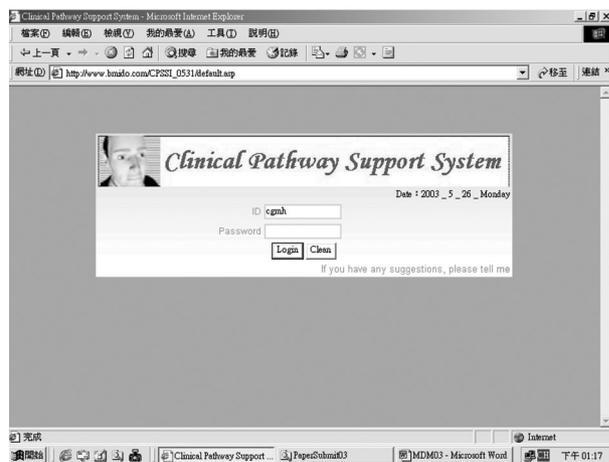


Fig. 1 Clinical pathway support system on the Internet (CPSSI).

METHODS

The CPSSI was developed using Active Server Pages (ASP) and Structured Query Language (SQL) Server 7.0. The CPSSI contains seven databases including the action category, case payment system, management, nursing, laboratory, medication, and surgical method databases. The databases of the case payment system, management, laboratory, medication, and surgical methods have a design similar to the databases of the Bureau of National Health Insurance (BNHI) in Taiwan. Users can use these databases to establish their own web-based clinical pathways. The CPSSI stores the data and assesses the pathway implementation automatically during clinical pathway implementation. The medical information used in developing the CPSSI is based on the knowledge and experience of physicians and on the scientific literature. The computer technology and web-based information were designed by the medical informatics team at Chang Gung Memorial Hospital.

The CPSSI homepage allows users to input information into the system via two channels. After entering their ID and password, users can use a single entry for all of the functions of the CPSSI, including creating, using, and modifying clinical pathways, performing system maintenance, altering personal data, providing system help, and assessing pathways. Meanwhile, other entry was used to perform limited functions, including using clinical pathways, patient records, altering personal data, system help, and pathway evaluation. Fig. 2 illustrates two entries of the CPSSI. The users were classified into two groups based on their entries and applications. Most users applying for access to the full CPSSI system were physicians and health care administrators. Meanwhile, users applying for access to the partial CPSSI system were generally nurses who needed to implement the clinical pathways. Physicians requested that nurses implement clinical pathways after developing a web-based clinical pathway using CPSSI for their department. Fig. 3 illustrates the flow chart for actions by CPSSI users. After implementing web-based clinical pathways, length of hospital stay, number of variations, and daily and monthly statistical reports were shown in the pathway assessment section of the CPSSI.

A web-based clinical pathway for radical prosta-

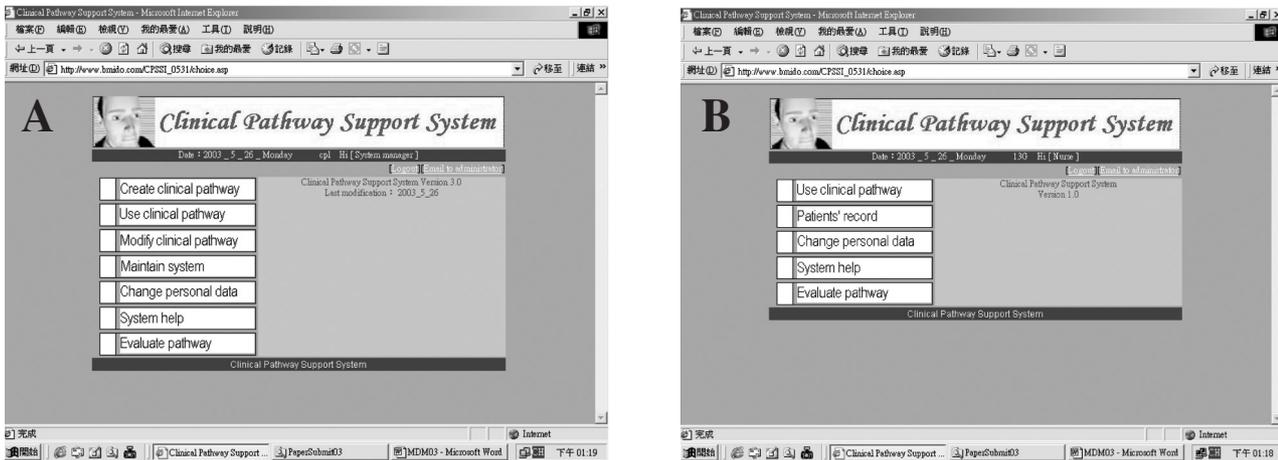


Fig. 2 Two entries for CPSSI users: (A) for whole functions of the CPSSI and (B) limited functions.

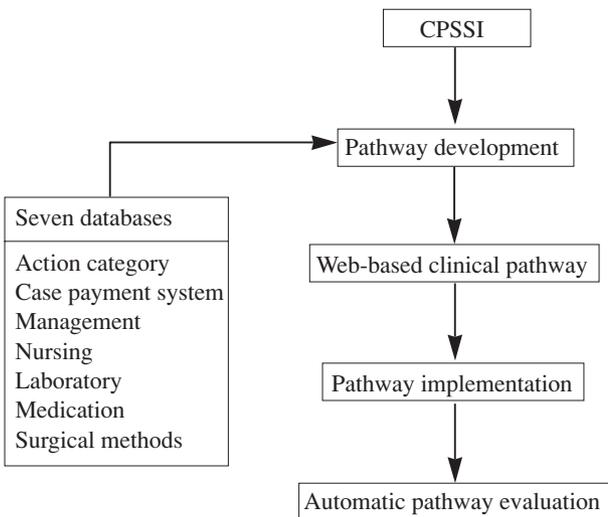


Fig. 3 CPSSI flow chart.

tectomy using CPSSI has been in place since June 2002. Upon admission of a patient scheduled for a radical prostatectomy, a ward nurse is assigned to educate the patient and their family about the web-based clinical pathway and the likely treatment outcome. This assessment is used to guide the expectations of the patient and his family regarding hospitalization.

A personal computer is located at the urological nursing station to provide access to the CPSSI. Urological nurses thus can easily record patient daily activity. The web-based clinical pathway for radical

prostatectomy is a form that schedules consultation times, laboratory tests, treatment, medication, activity, nutrition, elimination, education, psychosocial support, and discharge plans (Fig. 4). Patient daily activities are checked on the web-based clinical pathway. The assigned nurse identifies pathway variations. After the patient is discharged the nurse completes the web-based clinical pathway. Automatic assessment of the web-based clinical pathway implementation can be viewed on the Internet, and the results are stored on the web server. Furthermore, the CPDT can obtain the implementation results from the web server. The data, including length of hospital stay and number of variations, are e-mailed to the clinical physicians and nurses for reference.

The number of variations and average length of hospital stay are listed on the web-based clinical pathway. The nurses can check the variations using the daily reports provided by the pathway. If the variations can be corrected without affecting health outcomes, the nurses notify urology resident doctors and correct them immediately. If the variations can not be corrected immediately, nurses record them and consult with doctors to seek a resolution during a later meeting.

From June 2002 to June 2003, 22 consecutive patients with localized prostate cancer who underwent radical prostatectomy were treated with the web-based clinical pathway. To clarify the influence of the web-based clinical pathway on radical prostatectomy, the treatment results, including variations and length of hospital stay, were compared with

Actions/Expected LOS	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
Activity		∨ Bed rest	∨ Ambulate with assistance	∨ Ambulate independently	∨ Cont.	∨ Cont.	∨ Cont.	∨ Cont.	∨ D/C
Consults	∨ Anesthesia permit ∨ Nursing preparation ∨ Op. permit	× Consult R/T			× Dietary				∨ Discharge
Discharge planning	∨ Admit assessment							× Review discharge instructions	
Elimination	∨ Fleet enema								
Medications	∨ Send antibiotics to OR with patient CM	∨ Analgesics IM prn ∨ IV Antibiotics ∨ Foley care	∨ Cont. ∨ Cont. ∨ Cont.	∨ Cont. ∨ Cont. ∨ Cont.	∨ Cont.(oral) × Laxative ∨ Cont.(oral) ∨ Cont.	∨ Cont. ∨ Cont.	∨ Cont. ∨ Cont.	∨ Cont. ∨ Cont.	∨ D/C ∨ D/C ∨ D/C
Nutrition	∨ NPO since midnight	∨ NPO	∨ NPO	∨ NPO	× Diet as tolerated after flatus passage	× Cont.	∨ Cont.	∨ Cont.	∨ D/C
Psychosocial support	∨ Pat./family support	∨ Cont.	∨ Cont.	∨ Cont.	∨ Cont.	∨ Cont.	∨ Cont.	× Cont.	∨ D/C
Teaching	∨ Orientation ∨ Pre/post-op education	∨ Cont. ∨ D/C	∨ Cont.	∨ Cont.	∨ Cont.	∨ Cont.	∨ Cont.	∨ Cont.	∨ Review discharge medications ∨ Review discharge instruction ∨ F/U appoi.
Tests	∨ CBC/DC ∨ U/A ∨ BUN ∨ Cr ∨ GOT ∨ Sugar ∨ PT ∨ APTT ∨ Chest PA ∨ EKG	× Ht × Hb × K prn × Sugar prn × Cr prn	× Ht prn × Hb prn × Sugar prn × Cr prn						
Treatments	× Weight ∨ Vital signs ∨ Prepare blood ∨ IV fluid	× D/C × q1hx2, q2hx2, q4h ∨ Cont. ∨ Record I/O q8h ∨ On Foley	×.. × q8h ∨ Cont. ∨ Cont.	×.. × Ordinary ∨ Cont. ∨ Cont. ∨ Cont.	×.. ∨ Cont. ∨ Cont. ∨ D/C ∨ Cont.	×.. × D/C ∨ D/C			× Remove stitches ∨ Cont.
Variance			HB9.0 HCT 27.9 BUN26 CR1.9		Sip water	On diet DM --> check F/S			MBD
RN Signature	Lin	Lin	Lin	Lin	Lin	Lin	Lin	Lin	Lin

Fig. 4 Special form for the web-based clinical pathway for radical prostatectomy.

those for an identical sized sample of patients treated during the year before using the web-based pathway.

Non-parametric independent group analysis was applied to detect differences in variations before and after using the web-based pathway. Additionally, the independent Student's t-test was used to determine the statistical significance of the differences, including the mean patient age and length of hospital stay before and following the pathway implementation. The level of statistical significance was set as *p* value below 0.05. Statistical analysis was performed using SPSS V.12.0 for windows commercial software.

RESULTS

The urology physicians applied the CPSSI to establish the web-based clinical pathway for radical prostatectomy. The urological nurses implemented the clinical pathway on the Internet and recorded patient daily activities. Following pathway implementation, patient lists were displayed on the CPSSI, including chart number, name of attending doctor, admission date, discharge date, length of stay, and patient status. If the patient hospital stay exceeded expectations, a red sign appeared in front of the line recording patient details (Fig. 5). The results of the clinical pathway implementation were saved on the CPSSI server. Finally, the completed patient data was printed when the doctor of a specific patient requested a reference.

For evaluating the web-based clinical pathway for radical prostatectomy, the CPSSI automatically measured pathway variations and assessed the effects

序號	Attending Dr.	Admission Date	Discharge Date	Expected LOS	Actual LOS	患者狀態
18	3002805	2002/5/24		9 days	10 days	已出院(紅色)
20	3002805	2002/5/24		9 days	10 days	已出院(紅色)
21	3002805	2002/5/24		9 days	10 days	已出院(紅色)
96	3002805	2002/5/24		9 days	10 days	已出院(紅色)
27	3003104	2003/3/21		9 days	9 days	已出院(藍色)
28	3003105	2003/3/21 上午 08:31:00		9 days	9 days	已出院(藍色)
29	3002806	2002/5/17 下午 16:40:00		9 days	7 days	已出院(藍色)
50	3002510	2002/5/18 下午 04:03:00		9 days	9 days	已出院(藍色)
31	3003106	2003/3/20 下午 16:33:00		9 days	9 days	已出院(藍色)
72	3002116	2002/1/19 下午 16:48:00		9 days	12 days	已出院(藍色)
87	3003107	2003/3/25 下午 10:18:00		9 days	9 days	已出院(藍色)
34	3003107	2003/3/25 下午 09:40:00		9 days	10 days	已出院(藍色)
89	3002019	2002/2/27 下午 10:43:00		9 days	9 days	已出院(藍色)
77	3003102			9 days	10 days	請於出院前(紅色)
25	3002819	2002/5/20		9 days	10 days	已出院(藍色)
11	3002901	2002/5/26		9 days	10 days	已出院(藍色)
23	3002915	2002/5/27		9 days	10 days	已出院(藍色)
30	3002117	2002/1/15		9 days	9 days	已出院(藍色)
24	3003100			9 days	10 days	請於出院前(紅色)

Fig. 5 A red sign (arrow) appears in front of an overstaying patient.

of clinical pathway implementation on length of hospital stay. The daily and monthly statistical reports were displayed in the “evaluate pathway” section of the CPSSI. The daily report included clinical pathway name, chart number, number of positive and negative items, percentage variation, and length of hospital stay (Fig. 6). The monthly report also included patient number, average length of stay, and percentage variation.

The total number of patients admitted for radical prostatectomy following clinical pathway implementation was 22. The average hospital stay was reduced significantly after implementing the web-based clinical pathway (*p* = 0.0001). The mean number of variations differed significantly (*p* = 0.0002) before and after the implementation of the web-based clinical pathway. The Table 1 lists the detailed results.

CP Name	PID	No. Positive Items	No. Negative Items	% of Variance	LOS
utr	4402115	0	21	100	2
rebi	2217663	24	0	0.0	1
ra	4602046	25	0	0.0	1
ra	5112227	24	1	4.0	1
ra	2027026	0	20	100	2
rip	3473000	0	18	100	2
rip	3702028	0	18	100	2

Fig. 6 The daily report includes numbers of positive and negative items, percentage variation, and length of stay for a patient with a radical prostatectomy.

Table 1. Results before and after Web-based Clinical Pathway Implementation for Radical Prostatectomy

	before	after	<i>p</i> value
No. of patients	22	22	
Age (SD)	66 (± 3.75)	67 (± 2.97)	0.3776
Length of stay (day) (SD)	11.7 (± 1.59)	9.9 (± 1.21)	0.0001
Variations (mean ± SD)	(2.73 ± 0.94)	(1.77 ± 0.53)	0.0002

DISCUSSION

Web-based technology and information has been reported to enhance teaching in medical schools.⁽¹¹⁾ Additionally, web-based information can improve the utility and productivity of medical equipment and save time and money.⁽¹²⁾ However, to be successful, web-based clinical information must be relevant to the needs of patients, nurses, physicians, and health care providers. User needs are an important precursor to targeted web-based medical information.⁽¹³⁾ In this study, physicians and administrators used CPSSI to establish a web-based clinical pathway for radical prostatectomy. Furthermore, nurses implemented the pathway daily. Physicians and nurses can use CPSSI to assess the implementation of the web-based clinical pathway.

Health care consumers recently have begun to benefit from web-based communications tools to guide decision making related to medical examinations and treatments.⁽¹⁴⁾ An effective and reliable web-based clinical decision support system can enhance the management and coordination of patient encounters.⁽¹⁵⁾ The combination of clinical expertise and empirical evidence through web-based support systems can provide important medical resources for education, resident training and risk assessment. The medical information in the CPSSI is based on the knowledge and experience of physicians and on the scientific literature. The algorithms in the CPSSI were designed using a stepped approach, and were based on the thinking process of physicians. Physicians can easily create web-based clinical pathways using the CPSSI.

Clinical pathways have been reported to be an extremely useful tool for monitoring health outcomes, and have emerged as a successful strategy for enhancing care quality and cost-effectiveness.⁽¹⁶⁻¹⁸⁾ Our early experience in using clinical pathways to improve patient care achieved good results.⁽¹⁰⁾ To continuously achieve good health care, the improved results were carefully maintained by educating nurses, health care staff, and physicians regarding the pathway. Meanwhile, the methods and procedures involved in clinical pathway implementation were improved to reduce the workload on nurses. The web-based clinical pathway provides accurate information and rapidly detects variations during clinical

pathway implementation. Developing clinical pathways is a highly complex and multifaceted task. Therefore, the CPDT designed the CPSSI to enable physicians and administrators to create their own clinical pathways easily on the Internet. The databases for web-based clinical pathway creation in the CPSSI were designed based on those released by BNHI in Taiwan. Because these databases do not include certain expensive drugs and biomaterials which are not supported by BNHI, physicians can conveniently apply to the BNHI for these items if they use this clinical pathway.

The CPDT was a multidisciplinary committee comprising attending physicians, nurses and administrators.⁽¹⁰⁾ The team suggested that physicians and nurses should participate in developing and implementing clinical pathways. In the urological department, the preliminary clinical pathway was established by an urologist and sent to other attending physicians, nurses and the leader of the urological nursing department for review. The team finalized the clinical pathway based on the review results. Ward nurses then implemented the final clinical pathway in the urological wards. The procedure was that two entries were designed on the CPSSI. The clinical pathway creators entered full function CPSSI, and the nurses who implemented the pathways entered limited function CPSSI. Under the latter mode, the clinical pathway special form on the CPSSI cannot be modified. To improve CPSSI security, different passwords were used for both forms of entry.

Reduced hospital stay was generally associated with the use of clinical pathways.^(19,20) In our study, the main variations related to reducing hospital stay were “operation on second hospital day”, “review discharge instructions”, and “remove stitches”. These three variations will increase the length of hospital stay if they cannot be completed according to the pathway. Owing to shorter hospital stays, average hospital charges were also reduced and the cost-effectiveness of medical care was improved. Because of the importance of controlled hospital stay during clinical pathway implementation, a red sign was placed in front of the patient’s information in the list on the CPSSI when the hospital stay exceeded expectations. This sign reminded physicians and nurses to be alert for variations, and it disappeared following patient discharge.

This study found that the most common source of variation was patient-related variation. This variation can result from patient choice, patient anxiety, or inadequate social assistance.⁽²¹⁾ Variation detection was the main step in pathway implementation, because variations can influence length of hospital stay and/or cost of medical care.⁽¹⁰⁾ Reducing unnecessary variations after implementing clinical pathways may improve health outcomes.⁽⁸⁾ Consequently, this investigation established an automatic function for variation detection on the web-based pathway. The variations in the clinical pathway were displayed immediately in a daily report, as well as being summarized automatically in a monthly report. The daily report helped the physician and assigned nurse to check the clinical pathway variations. There were 60 variations among 22 patients before web-based clinical pathway implementation, and 39 after using the pathway. This reduction might result from easily identifiable variations on the web-based pathway and a focus by nurses on variation checking.

If the clinical pathway is found to contain numerous variations, the CPDT should modify the pathway to make it closer to the practice of physicians. If a pathway is variation free, the CPDT may need to modify the pathway to enhance care quality.

This investigation concludes that Internet-based clinical pathway support systems may be a good tool for creating and implementing web-based clinical pathways. The practice variations and length of hospital stay were reduced significantly following implementation of the web-based clinical pathway for radical prostatectomy. Automatic assessment of the effects of web-based clinical pathway implementation on variations and length of stay may induce clinical physicians and nurses to implement clinical pathways and thus enhance patient care quality.

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The web-based clinical pathway support system and the web-based clinical pathway for radical prostatectomy are available at <http://www.bmidoc.com/cpss>

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以網路為基礎的臨床路徑降低前列腺根除手術臨床照顧差異

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背景： 這一篇研究旨在評估以網路為基礎之臨床路徑 (Web-based clinical pathway) 和傳統無臨床路徑，病患所得到照顧的差異性。

方法： 我們利用網路建立一套臨床路徑決策支援系統 (CPSSI)，以此系統來建置以網路為基礎的臨床路徑，用來照顧接受前列腺根除手術之病患。本研究分析自 2002 年六月至 2003 年六月共 22 位病患，針對罹患早期前列腺癌，接受前列腺根除手術並且依照前列腺癌臨床路徑照護之病患，和尚未施行臨床路徑前一年的病人，比較兩組間接受到治療行為和治療結果的差異。

結果： 結果顯示根據 CPSSI 制定出來的臨床路徑可以明顯的降低住院天數，並且減少不同照顧者所造成的治療差異性，藉此可改善病患照顧的品質。

結論： 臨床路徑的實施可以明顯的降低住院天數，而以臨床路徑決策支援系統 (CPSSI) 可以藉由網路上即時監測各項指標，使得臨床路徑更能發揮其功效，更減少在治療上的差異，提升醫療品質。

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關鍵詞： 網路支援，臨床路徑，決策支援系統，健康預後