What to call spinal cord damage not due to trauma? Implications for literature searching

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Objectives: To illustrate the importance of multiple search terms and databases when searching publications on spinal cord damage not due to trauma. To develop comprehensive search filter for this subject, compare the results for 2000–2009 with the Medical Subject Headings (MeSH) and Emtree term 'spinal cord diseases' and determine changes in the number of articles over this period.
Design: Literature searches and search filter development.
Setting: Australia.
Interventions: Titles and abstracts searched in MEDLINE and EMBASE (2000–2009) for articles involving humans using search terms 'non-traumatic spinal cord injury' and 'nontraumatic spinal cord injury' (concise search). Develop comprehensive search filter for 'spinal cord damage not due to trauma' and compare the results with the MeSH term 'spinal cord diseases.'
Outcome measures: Annual publications (2000–2009) identified in MEDLINE and EMBASE literature searches.
Results: Concise search identified 35 articles published during 2000–2009. More publications were identified using the term 'nontraumatic spinal cord injury' ($n = 20$) than 'non-traumatic spinal cord injury' ($n = 16$). Publications increased for both terms 'spinal cord diseases' (2000 = 279; 2009 = 415) and 'spinal cord damage not due to trauma' identified by the comprehensive search filter (2000 = 1251; 2009 = 1921).
Conclusions: Concise searches using terms 'non-traumatic spinal cord injury' and 'nontraumatic spinal cord injury' fail to identify relevant articles unless combinations of terms and databases are used. These are inadequate search terms for a comprehensive search. Further research is needed to validate our comprehensive search filter. An international consensus process is required to establish an agreed term for 'spinal cord damage not due to trauma.'

Keywords: Information storage and retrieval, Spinal cord diseases, Spinal cord injury, Systematized nomenclature of medicine, Terminology

> *That which we call a rose by any other name would smell as sweet*.[1]

Although Shakespeare's perspective on names can be generalized to healthcare, there is a compromise when multiple non-standard terms are used to describe the same entity. In relation to spinal cord medicine, for example, evidence suggests that all patients with spinal cord damage, irrespective of their etiology (i.e. 'the name'), should be able to access specialist rehabilitation services without bias or discrimination.[2,3] However, patients with spinal cord damage not due to trauma do not always have this equity of access.[2,3] In addressing this, and other research agendas involving these patients, a major compromise occurs because there is no accepted general collective term for this group of disorders. It is essential, however, in healthcare to have consistent vocabulary and definitions to facilitate discussion and knowledge transfer among planners, managers, educators, clinicians, and researchers. This is extremely important with regard to having consistent terms for searching the literature, which is a vital component of evidence-based medicine.[4] Furthermore, efficient and timely access to pertinent information is a vital part of the evidence-based healthcare process. Clinicians and health planners have an enormous challenge in dealing with the volume of published information, particularly knowing where and how to search, and how to appraise the quality of information.[5]

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Searching the literature for publications regarding spinal cord medicine presents numerous challenges. The reasons for this include: it is a diverse field with many different phases, from emergency to acute care, rehabilitation, community integration, and lifetime reviews; there are many symptoms and complications; and it is a multidisciplinary field with many health professionals working in related clinical, academic, and research roles contributing to the knowledge base. In addition to the three main spinal cord-specific journals (*Journal of Spinal Cord Medicine, Spinal Cord, and Topics in Spinal Cord Injury Rehabilitation*), there are also many general rehabilitation, specialty medical, allied health, and nursing journals that publish in this field.[6] Identifying the relevant literature from these other sources is especially important as these journals may not be regularly read by spinal cord medicine clinicians.

Spinal cord damage not due to trauma is a sub-set of spinal cord medicine that has additional challenges when searching for relevant information. This is because they are a heterogeneous group of illnesses and diseases with varying pathophysiological mechanisms.[7] Research about these patients is vital because it is reported that this condition has a higher incidence than traumatic spinal cord injury (SCI), particularly in developed countries, and it is anticipated that the incidence will increase further as the population ages.[8]

Medical Subject Heading (MeSH) terms are the USA National Library of Medicine's standardized vocabulary for indexing articles in MEDLINE or PubMed (http://www.ncbi.nlm.nih.gov/mesh) (Table 1). MeSH uses the term 'spinal cord diseases' to cover the broad range of conditions that includes both 'spinal cord injury' (defined as a traumatic condition) and the various causes of spinal cord damage not due to trauma. 'Spinal cord injury' is a specified MeSH term and it appears at three locations in the hierarchy. There is, however, no single descriptor in the MeSH hierarchy to collectively describe spinal cord damage not due to trauma.

Emtree is compiled by Elsevier and is the corresponding hierarchical, structured, and controlled classification used for indexing in the EMBASE database (http://www.embase.com/) (Table 1). Emtree covers many publications not included in MEDLINE, particularly European-based journals. As with MeSH, there is no single descriptor that collectively describes spinal cord damage not due to trauma.

Patients with spinal cord damage not due to trauma are described in the literature using a number of different terms. These include nontraumatic spinal cord injury, non-traumatic spinal cord injury, spinal cord damage, spinal cord dysfunction, spinal cord lesion, medical paraplegia, and myelopathy.

The primary aim of this project was to highlight problems when searching the literature for articles about spinal cord damage not due to trauma in the absence of an agreed standardized search term. The first objective was to perform a literature search using commonly used concise search terms to illustrate the importance of using multiple search terms and multiple databases when searching for articles about spinal cord damage not due to trauma. The second objective was to develop a comprehensive search strategy for spinal cord damage not due to trauma and to compare this with a search using the MeSH and Emtree terms for 'spinal cord diseases,' which cover all causes of disease or damage to the spinal cord. The final objective was to assess whether there was an increase in the number of articles pertaining to spinal cord disease and spinal cord damage not due to trauma over the decade 2000–2009.

Methods

Concise search for spinal cord damage not due to trauma

A search of the MEDLINE and EMBASE databases was performed in December 2010 for the decade 2000–2009. These databases were chosen because they are the most comprehensive medical databases. The search terms chosen were 'non-traumatic spinal cord injury' and 'nontraumatic spinal cord injury.' These had been identified through multiple literature searches and reading of articles as the most frequently used phrases to describe this group of patients. The variations on the spelling (non-traumatic and nontraumatic) were searched within three words in either direction of 'spinal cord injur*,' truncated to allow for multiple suffices. This approach is recommended to select unexpected phrases,[4] e.g. non-traumatic post-acute SCI. The terms 'spinal cord lesion' and 'spinal cord dysfunction' were not used because these MeSH and Emtree terms also include traumatic SCI.

Publications in any language were included if the search terms were used in the title or abstract and if there was an abstract in English. There was no restriction on patient age or publication type. The search strategy excluded studies not involving humans. Duplicate publications were removed.

Identified abstracts were initially screened by a research assistant and classified as to whether they related to SCI not due to trauma. The research assistant was not given any formal training regarding the etiologies of spinal cord disease or the conditions that would

Table 1 Summary of key features of database hierarchies

Medical Subject Headings	Emtree
• Consists of sets of terms naming descriptors in an 11-level hierarchical structure that permits searching at various levels of specificity	• 15 Major branches or facets • The largest branch covers physical diseases, disorders and abnormalities
• Provides consistent way to retrieve information that may use different terminology for the same concepts	
• Descriptors arranged in both alphabetical and hierarchical structure. At the most general level of the hierarchical structure there are very broad headings. More specific headings are found at more narrow levels	• Includes all MeSH terms, but also has its own unique features, including the use of more natural language to describe terms and the use of many synonyms and spelling variants

be covered by the intended search. This was to establish the perspective of an inexperienced researcher. Subsequently, the principal author reviewed the abstracts and how they were categorized. When it was not possible to determine from the abstract whether the article should be included, the full text was obtained. Agreement between the research assistant and principal author was calculated as well as the unweighted kappa.

Comprehensive search filter for spinal cord damage not due to trauma

It has been suggested that highly sensitive search strategies might fail to detect relevant articles in diverse areas.[9] We believe that this applies to spinal cord damage not due to trauma. Therefore, during 6 years of performing multiple literature searches on this topic, we developed and refined what we hypothesize to be a comprehensive search strategy or filter for spinal cord damage not due to trauma (Appendix).

The search filter has separate components based on MEDLINE and Entree terms. In MEDLINE, for spinal cord hemorrhage indexers use 'Hemorrhage/ AND Spinal Cord Diseases/.' In EMBASE the term spinal cord hemorrhage/ is used. We did not use 'hemorrhage' as a text word because the MeSH term is identical and caters for variant spellings. We limited these terms to titles and/or abstracts to avoid institution names before 'AND'-ing them to the SCI and spinal cord disease terms. Regarding the variations of 'non-traumatic SCI,' we deliberately chose to be transparent in preference to using a wildcard symbol to cover one or no spaces after 'non' and to truncate trauma to cover trauma, traumas, traumatic, etc. We tested 'nontraumatic' and 'non?traumatic' and the results were the same without the hyphen. We identified search terms by sequentially reviewing the hierarchical tree structures within each database. Again, to maintain transparency, we listed the terms separately rather than 'exploding' them to avoid specific terms. From the MeSH tree, we chose the terms most relevant to spinal damage not due to trauma. For the terms that can also be associated with traumatic SCI (spinal cord compression, spinal cord lesion, paralysis, and syringomyelia), we avoided using the 'NOT' Boolean operator with these etiologies and the term SCI. This was because we did not want to exclude publications that included comparisons between patients with the above-listed conditions due to either of the etiology categories.

A search using our comprehensive strategy was performed in both the MEDLINE and EMBASE

Table 2 Number of articles identified in different years using different databases and different concise search terms for spinal cord damage not due to trauma

	Search term	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
1	Non-trauma* adj3 spinal cord injur*.ti,ab.	1	0	1	1	0	2	1	1	4	5	16
2	Nontrauma* adj3 spinal cord injur*.ti,ab.	1	2	4	1	4	2	1	4	1	0	20
3	1 or 2	2	2	5	2	4	3	2	5	5	5	35
4	Non-trauma* adj3 spinal cord injur*.ti,ab. – MEDLINE only	0	0	0	0	0	0	0	0	0	0	0
5	Non-trauma* adj3 spinal cord injur*.ti,ab. – EMBASE only	1	0	1	0	0	0	0	0	2	1	5
6	Nontrauma* adj3 spinal cord injur*.ti,ab. – MEDLINE only	0	0	0	0	0	0	0	0	0	0	0
7	Nontrauma* adj3 spinal cord injur*.ti,ab. – EMBASE only	0	0	0	0	1	1	0	0	1	0	3
8	Search 3 – MEDLINE only	0	0	0	0	0	0	0	0	0	0	0
9	Search 3 – EMBASE only	1	0	1	0	1	1	0	0	3	1	8

databases, with duplicates removed, limited to search terms appearing in the title or abstract, and excluding studies not involving humans. For comparison purposes, this search was compared with a search using the MeSH and Emtree search term 'spinal cord diseases,' which is the global term used in these databases for spinal cord damage or injury from any cause. Both searches covered the decade 2000–2009 and used the same inclusion and exclusion criteria.

Results

The concise search for non-traumatic and nontraumatic spinal cord injury identified 37 publications in MEDLINE and EMBASE for the decade 2000–2009. Two abstracts were excluded because they did not pertain to spinal cord damage not due to trauma. In one case, the full text needed to be obtained to make the final determination. There were more articles (n = 20) identified using the search term 'nontraumatic SCI' than with 'non-traumatic SCI' (n = 16) (Table 2). One publication was identified by both search terms. The EMBASE search identified numerous articles that were not indexed in MEDLINE. The agreement between the principal researcher (P.W.N.) and research assistant in including or excluding publications the same way was 81%, with an unweighted kappa of 0.30 (P = 0.005), corresponding to a fair agreement.[10] It would appear that there was an increase in publications using the concise search terms over the decade 2000–2009.

Our comprehensive search filter for spinal cord damage not due to trauma (Appendix) identified many more articles – by a factor of approximately four – than the general search term used in MeSH and EMBASE for spinal cord diseases (Table 3). For both of these searches, there was a very obvious increase in the number of publications during the study period.

Discussion

We have found that the different concise terms used by authors, and approved by editors, to refer to spinal cord damage not due to trauma results in a suboptimal response when attempting to identify all potentially relevant publications. A comprehensive search filter for spinal cord damage not due to trauma identified many more articles than the general MeSH or EMBASE term for spinal cord diseases. Over the past decade, there has been a substantial increase in the publication of articles about spinal cord damage not due to trauma.

When facing the challenges of searching medical databases for information,[5,11,12] our findings reinforce

Table 3 Comparison of publications identified using the general term for spinal cord damage from any cause with the comprehensive search strategy for spinal cord damage not due to trauma

	Search term	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
1	Spinal cord diseases/*OR spinal cord disease*.ti,ab.	279	299	371	365	376	347	412	411	414	415	3689
2	Comprehensive search strategy for spinal cord damage not due to trauma**	1251	1292	1396	1477	1550	1621	1676	1712	1795	1921	15 691

*MeSH heading.
**Appendix 2. Search run using Ovid: MEDLINE to November week 3, 2010 and EMBASE week 50, 2010.

previous recommendations regarding the need to utilize both of the two main medical databases to optimize the identification of relevant publications.[13,14] Although our concise search in MEDLINE failed to identify any unique articles not in EMBASE, it is important to point out that this search was primarily for illustrative purposes. Our results illustrate the consequences of failing to utilize all relevant terms when performing an electronic search. They also highlight the importance of researchers enlisting the advice of an experienced health librarian to assist in designing search strategies to avoid missing relevant articles (optimized sensitivity) and to reduce the occurrence of unnecessary irrelevant articles (optimized specificity).[15] The omission of databases or search terms results in incomplete identification of relevant publications and creates an information bias in those performing the search.

It has previously been suggested that database producers seek the involvement of rehabilitation physicians when creating or correcting the structure of their keywords.[13] These investigators advocated the need for an additional level to the hierarchy used in both databases for a section gathering all relevant descriptor terms concerning disability and therapeutic devices. We concur with these recommendations.

The challenge of using search strategies to identify articles regarding traumatic SCI has been reported in a study that focused on the difficulties in locating articles pertaining to traumatic SCI and chronic pain in humans.[6] By reviewing the abstracts, reviewers could only determine in 37% of articles whether the paper reported on traumatic SCI. By comparison, we were able to determine the etiology of spinal cord damage in 97.3% (36 of 37) of articles in this study. This difference may be due to a general improvement in abstracts in the intervening period. Another explanation may be that authors writing about the subject of our search recognized the importance of specifying the nature of the SCI etiology in their abstracts.

Subject search filter for spinal cord damage not due to trauma

The challenge of searching the literature for publications about spinal cord damage not due to trauma suggests a potential role for a subject search filter to assist in locating relevant publications. Search filters were initially developed in the 1990s to help researchers identify publications pertaining to particular methodological designs, such as prevention, diagnosis, treatment, prognosis, systematic reviews, and randomized controlled trials.[16–18]

It was beyond the scope and intent of this project to review all the articles identified using our search filter. What we set out to achieve by making the comparison with the general search results was to highlight the potential to miss many relevant publications if a suboptimal search strategy is used. As explained previously, this is important for the practice of evidence-based medicine.

We have developed the first reported 'first-generation' subject search filter[18] for spinal cord damage not due to trauma. It is important to highlight that simply using a broad search term (e.g. 'spinal cord diseases') and excluding traumatic SCI would eliminate comparison studies between these groups, which is not desirable. Our search filter forms the basis for a gold standard search filter. Despite the limitations detailed below, we suggest that researchers consider using our proposed comprehensive subject search filter and combine it with methodological filters and other search terms particular to their research question to optimize their search results when a thorough and comprehensive literature search in this field is required.

What to call spinal cord damage not due to trauma?

The Centres for Disease Control in the USA defines SCI as 'the occurrence of an acute, *traumatic lesion* (italics added for emphasis) of neural elements in the spinal canal (spinal cord and cauda equina) resulting in temporary or permanent sensory deficit, motor deficit, or bladder/bowel dysfunction.'[19] This definition specifically excludes causes not due to trauma. The MeSH and Emtree hierarchies also adopt a similar definition of SCI referring specifically to a traumatic etiology. Neither of these hierarchies includes a general term that collectively refers to all causes of spinal cord damage not due to trauma.

There is a conflict, therefore, between the definition of 'spinal cord injury' and the commonly used terminology for referring to causes of spinal cord damage not due to trauma ('non-traumatic spinal cord injury'). Whether it will be 'spinal cord damage,' 'spinal cord myelopathy,' or some other phrase, a universally accepted term for this group of conditions is needed to assist researchers in locating relevant information in this field, as well as to improve communication between relevant stakeholders.

> *'When I use a word,' Humpty Dumpty said in rather a scornful tone, 'it means just what I choose it to mean – neither more nor less.'*
>
> *'The question is,' said Alice, 'whether you can*

make words mean so many different things.'

'The question is,' said Humpty Dumpty, 'which is to be master – that's all.'[20]

Limitations

We did not review the full text of all abstracts identified by the concise search for spinal cord damage not due to trauma, only the single case where it was not clear from the abstract whether the article met the criteria. Although it has been reported that there are inconsistencies between abstracts and the full text,[21] abstracts are the component of articles most likely to be read,[21,22] and often the only part that is read.[15,23] In addition, we did not review the abstracts identified by the comprehensive search filter to determine the sensitivity, specificity, accuracy, or precision.

We acknowledge that SCI not due to trauma forms a heterogeneous group of conditions. There is heterogeneity regarding the pattern of onset of spinal cord damage. Patients can have acute onset over seconds, minutes, or hours, a subacute onset over days, or a chronic onset over weeks or longer. There is also heterogeneity regarding the completeness of spinal cord damage as well as the multiple possible causes.[7] Some patients can have both traumatic and nontraumatic factors contributing to their spinal damage. For example, a patient with cervical myelopathy that results in a fall can sustain a central cord syndrome. It can be argued, however, that traumatic SCI also has a large degree of heterogeneity. Consider the variation associated with the risk factors, prevention programs, pattern of onset, severity of injury, prognosis, and outcomes in patients who have the following types of traumatic SCI: (1) multi-trauma due to a high-speed motor vehicle accident resulting in a ventilator-dependent complete high tetraplegia; (2) a central cord syndrome in an elderly person who trips on a step; (3) a radiation-induced myelopathy; and (4) a low incomplete paraplegia as a complication of an epidural injection.

The terms used in the comprehensive search strategy do not cover all the etiologies of SCI not due to trauma. We excluded poliomyelitis, congenital, and genetic causes. Our focus was on information that would be clinically relevant for the typical patients that present to a spinal rehabilitation unit for inpatient rehabilitation after recent onset of spinal cord damage.

Conclusions

We recommend that further research be undertaken to devise the optimum search strategies needed to identify the literature about patients with SCI not due to trauma, as outlined above. Work is required to test and validate our search filter against an established gold standard. This requires the identification of publications by hand searching a range of target journals[18] to determine and optimize the sensitivity, specificity, precision, and accuracy. Subsequently, it will be possible to refine the search terms to produce a 'second generation' subject search filter. This work has been conducted in other fields faced with similar challenges to locating relevant publications, including palliative care[24] and sleep.[25]

We strongly recommend that an international consensus process is warranted to determine the most appropriate term to describe spinal cord damage not due to trauma. This process should include a wide range of relevant stakeholders. These include, but are not limited to the following: the International Spinal Cord Society; National Library of Medicine; Elsevier Bibliographic Databases; and the editors of major peer-reviewed medical journals that publish SCI literature.

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Appendix

See Table 4.

Table 4 Proposed 'gold standard' comprehensive search strategy for spinal cord damage not due to trauma

MEDLINE	
1	Non-trauma*.ti,ab.
2	Nontrauma*.ti,ab.
3	1 or 2
4	Spinal cord diseases/
5	Spinal cord injuries/
6	3 and 4
7	3 and 5
8	Hemorrhage/
9	4 and 8
10	Epidural abscess/
11	Myelitis/
12	Myelitis, transverse/
13	Paraparesis, tropical spastic/
14	Spinal cord compression/
15	Spinal cord neoplasms/
16	Epidural neoplasms/
17	Spinal cord vascular diseases/
18	Anterior spinal artery syndrome/
19	Spinal cord ischemia/
20	Syringomyelia/
21	6 or 7 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20
22	Animals/
23	Humans/
24	22 and 23
25	23 not 24

Continued

Table 4 ***Continued***

MEDLINE	
26	21 and 25
27	Limit 26 to abstracts
28	Limit 27 to yr = '2000–2009'
EMBASE	
29	Spinal cord disease/
30	Spinal cord injury/
31	3 and 29
32	3 and 30
33	Spinal cord hemorrhage/
34	Epidural abscess/
35	Cervical myelopathy/
36	Hydromyelia/
37	Myelitis/
38	Tropical spastic paraparesis/
39	Spinal cord compression/
40	Spinal cord atrophy/
41	Spinal cord cyst/
42	Spinal cord infection/
43	Spinal cord lesion/
44	Spinal cord malformation/
45	Spinal cord tumor/
46	Spinal cord vascular disease/
47	Spinal paralysis/
48	Syringomyelia/
49	31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48
50	Animal/
51	Human/
52	50 and 51
53	51 not 52
54	49 and 53
55	Limit 54 to abstracts
56	Limit 55 to yr = '2000–2009'
57	28 or 56

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