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Научный обзор

Скрининг на юношеский идиопатический сколиоз (обзор литературы)

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Обоснование. Несмотря на более чем шестидесятилетний период существования скрининга на юношеский идиопатический сколиоз, эта тема до сих пор вызывает споры в научной литературе. Существуют как противники, так и сторонники этого мероприятия в лице государственных структур, врачебных организаций и отдельных исследователей. Ряд стран отказались от национального скрининга на сколиоз, хотя отдельные врачебные объединения в этих же странах считают, что скрининг по модели «Медицинский дом» целесообразен. В противовес в целом ряде стран в национальных масштабах проводится школьный скрининг на сколиоз. В связи с отсутствием единого взгляда на данную проблему представляется целесообразным систематизировать разноречивые мнения по скринингу на юношеский идиопатический сколиоз.

Цель — проанализировать публикации, посвященные скринингу на юношеский идиопатический сколиоз, для определения круга нерешенных организационных вопросов.

Материалы и методы. Осуществлен поиск данных в открытых электронных базах научной литературы eLIBRARY, PubMed и Cochrane Library по ключевым словам и словосочетаниям: скрининг сколиоза, скрининг на юношеский идиопатический сколиоз, школьный скрининг на сколиоз, программа школьного скрининга на сколиоз [scoliosis screening; screening for adolescent idiopathic scoliosis (AIS); school screening for scoliosis; school scoliosis screening program]. Глубина поиска составила 30 лет.

Результаты. Аргументы «за» основаны на необходимости раннего выявления юношеского идиопатического сколиоза с учетом успешности своевременного лечения, доказанной эффективности консервативного лечения сколиоза и уменьшения количества хирургических вмешательств среди выявленных при скрининге подростков. Аргументы «против» связаны с отсутствием единой методики проведения скрининга, со значительной долей ложноположительных и ложноотрицательных результатов, недоказанностью эффективности скрининга с точки зрения снижения частоты хирургических вмешательств, экономической целесообразности, а также с психологическим воздействием на подростка и нарушением его прав при проведении мероприятия.

Заключение. Следует решить целый ряд организационных вопросов. К ним относятся подготовка кадров для осуществления скрининга, разработка системы направления на обследование и последующее наблюдение. Схема и методы проведения скрининга необходимо унифицировать посредством внедрения неинвазивных методов обследования с целью стандартизации получаемых результатов и их последующей единой интерпретации. Процесс направления на дальнейшее обследование также должен быть стандартизирован в соответствии с определенным протоколом. Актуальна разработка специальной компьютерной программы для помощи в принятии врачебных решений.

Ключевые слова: сколиоз; скрининг; программа; школьный скрининг; юношеский идиопатический сколиоз.

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Review

Screening for adolecent idiopathic scoliosis: A literature review

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BACKGROUND: Despite more than 60 years of screening for adolescent idiopathic scoliosis, it is still a controversial issue in the scientific literature. There are both opponents and supporters of the intervention, represented by government agencies, medical organizations, and individual researchers. Several countries have rejected national scoliosis screening, although some medical associations in these countries believe that screening based on the "Medical Home" model is feasible. By contrast, school-based scoliosis screening has been implemented nationally in a few countries. Given the lack of consensus on this issue, it is useful to systematize conflicting views on screening for adolescent idiopathic scoliosis.

AIM: This study aimed to review publications presenting information on the status of screening for juvenile idiopathic scoliosis to identify unresolved organizational issues.

MATERIALS AND METHODS: Data were searched in the open electronic scientific literature databases (eLIBRARY, PubMed, and Cochrane Library) using the following keywords and phrases: scoliosis screening; screening for adolescent idiopathic scoliosis (AIS); school screening for scoliosis; school scoliosis screening program. The depth of the search was 30 years.

RESULTS: Arguments "for" focus on the need for the early detection of AIS through screening in terms of the effectiveness of timely treatment, proven efficacy of conservative treatment of scoliosis, and reduction of surgical interventions among screened adolescents. The arguments "against" are related to the lack of a unified methodology for screening, high rate of false-positive and false-negative results, unproven effectiveness of screening in reducing the frequency of surgical interventions, economic efficiency, and psychological effect on adolescents and violation of their rights during the event.

CONCLUSIONS: Several organizational issues should be addressed with regard to screening. These include the training of staff who conducts the screening and development of a referral and follow-up system. The screening scheme and methods should be unified through the introduction of noninvasive screening methods to standardize the results and their subsequent uniform interpretation. The referral process for further examination should be standardized according to a defined protocol. The development of a special computer program to assist medical decision-making is relevant.

Keywords: scoliosis; screening; program; school screening; adolescent idiopathic scoliosis.

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科学审查

青少年特发性脊柱侧凸筛查（文献综述）

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论证。尽管青少年特发性脊柱侧凸筛查已有六十多年的历史，但这一话题在科学文献中仍引起争议。这项措施既有反对者，也有支持者，其代表有政府机构、医疗组织和个人研究者。一些国家已经放弃了脊柱侧弯的全国性筛查，尽管这些国家的个别医生协会认为，基于Medical home模式的筛查是合适的。相比之下，一些国家正在全国范围内进行基于学校的脊柱侧弯筛查。鉴于在这一问题上缺乏统一的观点，将关于青少年特发性脊柱侧凸筛查的不同观点系统化似乎是合适的。

目的。本研究旨在回顾有关青少年特发性脊柱侧凸筛查的出版物，以确定一系列尚未解决的组织问题。

材料与方法。使用关键词和短语：脊柱侧凸筛查、青少年特发性脊柱侧凸筛查、学校脊柱侧凸筛查、学校脊柱侧凸筛查计划，在开放的电子科学文献数据库eLIBRARY、PubMed和Cochrane Library中进行了数据检索。搜索深度为30年。

结果。支持筛查的论点基于早期发现青少年特发性脊柱侧凸的必要性，同时考虑到及时治疗的成功率、脊柱侧凸保守治疗的有效性以及通过筛查发现的青少年手术干预的减少。反对筛查的论点与缺乏统一的筛查方法有关，假阳性和假阴性结果占很大比例，筛查在降低手术频率、经济可行性方面的有效性缺乏证据，以及对青少年的心理影响和活动期间侵犯他的权利。

结论。需要解决一些组织问题。这些问题包括对工作人员进行筛查培训，以及建立转诊和跟踪系统。筛查的设计和方法应通过采用非侵入性筛查方法加以统一，以便使筛查结果标准化，并随后对结果进行统一解释。转诊进一步检查的程序也应根据明确的协议进行标准化。需要开发一种专门的计算机程序，以协助医疗决策。

关键词：脊柱侧凸；筛查；计划；学校筛查；青少年特发性脊柱侧凸。

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论证

预防有待手术矫正的严重青年特发性脊柱侧凸(adolescent idiopathic scoliosis，AIS)是脊柱畸形治疗医生面临的重要任务。脊柱侧凸的早期发现非常重要，因为如果长期不进行治疗，疾病可能会恶化，在某些情况下最终需要进行手术治疗并致残。

美国医学博士G.D. MacEwen在青年特发性脊柱侧凸筛查的发展过程中发挥了重要作用，他于20世纪60年代在特拉华州所有学校实施了该计划[1]。1963年，Aitken开始在Minnesota的约10000人口中进行更大规模的脊柱侧弯筛查[2]。自1984年以来，美国矫形外科医师学会(American Academy of Orthopaedic Surgeons，AAOS)和脊柱侧弯研究学会(Scoliosis Research Society，SRS)一直赞同对学龄儿童进行脊柱侧弯筛查以早期发现脊柱侧弯的理念[3]。

尽管青年特发性脊柱侧凸筛查的历史可以追溯到60多年前，但围绕这一问题的争议直到今天仍未平息。即使在脊柱侧弯筛查的先驱美国，对这一问题也有不同的看法。例如，2004年美国预防服务工作组(United States Preventive Services Task Force，USPSTF)反对对无明显青年特发性脊柱侧凸症状的青少年进行定期筛查，理由是筛查的预后价值低，疾病进展的儿童比例相对较小，而且可能会进行不必要的治疗，包括穿紧身胸衣[4]。2018年的最新声明也阐明了这一立场[5，6]。然而，2007年，AAOS、SRS、北美儿童矫形学会(POSNA)和美国儿科学会(AAP)发表了一份内容翔实的声明，介绍了青少年特发性脊柱侧弯早期发现的优势和保守治疗的有效性，从而证明了筛查AIS的可行性[7]。2013年SRS[8]、2017年和2019年AAP[9]均重申了这一立场。

在这方面，我们认为应该分析与青年特发性脊柱侧凸筛查有关的出版物，从不同政府机构、医疗组织和作者的立场来考虑筛查问题。

目的是审查有关青年特发性脊柱侧凸筛查的出版物，以确定一系列尚未解决的组织问题。

材料和方法

在开放式电子科学文献数据库eLIBRARY、PubMed和Cochrane Library中使用以下关键词和短语对数据进行了检索：脊柱侧凸筛查、青少年特发性脊柱侧凸筛查、学校脊柱侧凸筛查、学校脊柱侧凸筛查计划。纳入标准：随机对照试验和对照试验、系统综述、脊柱侧弯主要科学协会的咨询、信息和方法资料。共审查了61篇包含青年特发性脊柱侧凸筛查信息的俄文和英文资料(文章全文、论文和文章摘要)。资料样本主要限于1990-2021年间。1990年以前出版的资料，如果包含了后来出版的资料中没有反映的有关AIS筛查的开创性或历史性数据，也被纳入审查范围。

结果

最初，我们通过关键词筛选出387篇文章，并根据纳入标准从中生成了一份包含6篇出版物的最终清单。其中包括回顾性对照队列研究(12篇)、前瞻性对照队列研究(10篇)、横断面研究(5篇)、共识研究(4篇)、病例对照研究(2篇)、系统综述(16篇)和单个病例报告(1篇)。其余11篇出版物是关于青年特发性脊柱侧凸筛查的建议(5)和信息(4)声明以及指导材料(2)。对这些材料进行分组是为了找到一些问题的答案。

- *谁建议或不建议进行青年特发性脊柱侧凸筛查？反对或赞成筛查的主要理由是什么？*
- *筛查使用什么方法，放射诊断所依据的参数值是多少，假阳性和假阴性结果的频率是多少？*
- *筛查的有效性与手术治疗的必要性有什么关系？*
- *脊柱侧弯筛查在经济上是否可行？*

观察

谁建议或不建议进行青年特发性脊柱侧凸筛查？反对或赞成筛查的主要理由是什么(表1)。

我们所讨论的问题是全球性的[19，20]，影响到数百万人[21-23]，但不同国家的处理方式各不相同。在保加利亚、荷兰、保加利亚、中国、希腊、印度、意大利、日本、马来西亚、西班牙、土耳其、新加坡、西班牙、瑞典和荷兰，通过立法在全国范围内对学龄儿童进行筛查，以早期发现病变[24]。

表1. 关于“脊柱侧弯筛查：推荐还是不推荐？”问题的综合数据

不建议或拒绝进行脊柱侧凸筛查（主要论点的措辞）	
美国预防服务工作组（USPSTF）[5，6]	如果提供服务，患者应了解有关利益和伤害比例的不确定性
大不列颠联合王国国家筛查委员会，2016 [10，11]	关于脊柱侧凸治疗效果的优质证据很少，这意味着特发性脊柱侧凸患者有可能接受不必要的无效治疗[12]
澳大利亚国家健康与医学研究委员会，2002 [13]	没有足够的随机临床试验证明筛查测试和保守治疗的疗效
加拿大预防保健特别工作组，1994 [14]	没有足够的证据来明确决定赞成还是反对
建议进行的监督检查（提出主要论据）	
美国儿科学会（AAP），2017，2019 [9]	预防性检查中的整个青春期脊柱侧弯检查
脊柱侧弯矫形与康复治疗学会（SOSORT），2016，2018年出版[15]	根据2007年SOSORT筛查共识文件[16]，建议学校实施以下计划
美国矫形外科医师学会（AAOS）、脊柱侧弯研究学会（SRS）、北美儿童矫形外科学会（POSNA），2015 [7，8]	建议家庭医生在家中使用 - Medical home model
SRS，2013 [17]	根据2013年关于SRS筛查的共识文件和系统综述[18]，建议实施学校计划

与此相反，美国预防服务机构[5，6]、英国国家筛查委员会[10，11]和澳大利亚国家健康与医学研究委员会[13]都认为脊柱侧弯筛查不应该是全国性的。奥地利、加拿大、法国、德国、以色列、挪威、波兰和西班牙[16]也遵循同样的脊柱侧弯筛查原则。俄罗斯也奉行非全国性脊柱侧弯筛查原则；国内科学文献仅提供了地区范围内的筛查研究信息[25-27]。

在对此类筛查没有全国性要求或标准的国家，州、县、市或个别学校可能会强制要求进行筛查[28]。筛查可以在儿科医生、脊椎治疗师或其他保健专业人员的办公室进行，通常不在学校内进行。一项针对SOSORT专家的调查显示，筛查检查最常由学校护士（48.57%）、理疗师（28.57%）、矫形外科医生（17.14%）和体育教师（11.42%）进行，而由注册护士、校医和保健中心工作人员进行的情况较少[16]。

在这方面，澳大利亚脊柱侧弯协会（Spine Society of Australia）的经验很有意思，该协会在澳大利亚皇家全科医师学院（Royal Australian College of General Practers）的支持下，制定了一项全国脊柱侧弯自我检测计划。网站http://www.scoliosis-australia.org上有专门的科普小册子，11-13岁的青少年或其父母在阅读后可以怀疑是脊柱侧弯症，并与家庭医生联系。同时，网站还为家庭医生组织了脊柱侧弯筛查诊断培训。英国脊柱侧凸协会（British Scoliosis Society）的网站上也为患者创建了类似的虚拟办公室--http://www.britscoliosis.org.uk。

反对筛查（包括学校筛查）的作者提出了筛查的不道德性和青少年脆弱易受伤害的问题[29，30]，更普遍的是在筛查中需要尊重儿童的权利[31]。在这方面，SRS推荐的Medical home模式[7，8]被认为是家庭医生实施筛查的首选形式。据指出，筛查测试应为民众所接受，治疗方法应为患者所接受[32-34]。

脊柱侧弯筛查的支持者声称，早期发现脊柱侧弯并及时采取保守治疗可减少手术干预的频率，降低脊柱侧弯的严重程度，这一点已被系统回顾、回顾性和前瞻性临床研究证实[2，3，16，35，36]。

哪个年龄段的孩子要做脊柱侧弯筛查？（表2）。

尽管J.A. Deurloo和P.H. Verkerk[12]的系统综述显示，脊柱侧弯筛查的最佳年龄和频率仍是未知数，然而，从表2中可以看出，大多数专家坚持女孩应该在12岁开始筛查，男孩应该在13岁。

表2. 脊柱侧弯筛查的建议年龄

社会或作者	建议年龄
美国矫形外科医师学会（AAOS）、脊柱侧弯研究学会（SRS）、北美儿童矫形外科学会（POSNA），2015 [7, 8]	女孩在10岁和12岁之间。 男生在13至14岁检查1次
美国儿科学会（AAP），2017，2019 [9]	10岁、12岁、14岁和16岁的常规医疗预约
脊柱侧凸矫形与康复治疗学会（SOSORT），2007 [16]	女孩12岁，男孩13岁
J. Sabirin et al.，2010 [3]	12岁女孩
T.B. Grivas et al.，2002，2006 [37, 38]	对生活在北方国家的女孩进行筛查的年龄范围应比生活在南方的女孩大

使用什么方法进行筛查，放射诊断所依据的参数值是多少，假阳性和假阴性结果的频率是多少?(表3)。

通过分析表中的数据，我们可以得出这样的结论：倾斜测量法--测量站立和前屈位时躯干旋转的最大角度（Angle of Trunk Rotation--似乎是确定躯干畸形的最简单、最快速、最可靠、成本最低且最客观的方法，被广泛用于青年特发性脊柱侧凸筛查[3, 16, 17, 37, 40-47]。同时，一些学者认为5° 的角度是阈值[41-43, 45-47]，一些论文规定了5-7° 的间隔[17, 40, 43]，在SOSORT共识研究中，建议在坐姿而不是站立时使用脊柱侧凸仪进行研究[16]，J. Sabirin等人[3]的文章也建议使用脊柱侧弯仪。萨比林等人[3]、T.B. Grivas等人[37]、I.S. Komang-Agung等人[43]的文章采用7° 作为临界值。尽管Adams（Forward Bend Test）[47]的特异性相当低，但它是历史上最早用作筛查试验的试验之一[1, 2]，至今仍被研究人员提及[43-46]。多位作者认为，随着筛查试验次数的增加，其敏感性和特异性增强，假阳性和假阴性的比例降低[44, 47]。

主要争议在于假阳性和假阴性筛查结果。这些结果是反对者的主要论据。正如W.P. Bunnell[48]所言，虽尽管临床变形与X线测量之间存在显著相关性，但标准差如此之大，以至于无法可靠地从任何患者的表面形貌来预测弯曲程度。为了避免假阳性，作者建议在6-12个月时到学校重复筛查，而不是转诊进行放射检查。

SOSORT还报告称，在典型筛查条件下，每检测到一条曲线>10°，就会出现1-5个假阳性；同样，每检测到一条曲线>20°，就会出现3-24个假阳性[16]。加拿大M. Beausejour等人[53]报告称，在489例疑似青年特发性脊柱侧凸患者中，206例（42%）无明显畸形（Cobb角<10°），作者将其评估为不适当转诊。

SOSORT认为，学校筛查计划的目的是检测浅表的躯干畸形，而不是预测哪些脊柱侧弯会发展，随后可能导致需要进行保守治疗或手术治疗[16]。

根据AAOS、SRS、POSNA和AAP的规定，在对儿童脊柱进行放射影像诊断以诊断脊柱侧凸时，应采用ALARA（As Low As Reasonably Achievable）原则，以减少辐射剂量[49]。

除上述脊柱侧弯筛查试验外，还提出了许多设备和方法，包括基于DNA微阵列的分子遗传学试验[50, 51]。然而，进行这些检测所需的时间和成本使其不适合大规模筛查。正如H.R. Weiss[52]所指出的，我们绝不应试图用昂贵的基因筛查方法来取代学校筛查；这些方法对于预测脊柱侧弯的进展可能很有用。

筛查对手术治疗的有效性如何?

对于筛查的有效性与手术治疗的必要性，专家们有不同的看法。在支持筛查的研究中，G. Torell等人的研究[54]对特发性脊柱侧凸早期发现和治疗计划的效果进行了评估，该计划覆盖150万人口，为期十年。在此期间，725名脊柱侧弯超过20°（用Cobb法测量）的患者在20岁之前就被发现。虽然治疗原则基本保持不变，但需要手术治疗的患者比例却逐年下降。马来西亚研究人员J. Sabirin等人[3]也发现，学校脊柱侧弯筛查计划有助于减少手术干预的需求。然在此过程中，筛查发现患者的手术

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表3. 按时间顺序排列的筛查检验信息、参数值、灵敏度和特异性

作者	作者推荐的筛查测试(+)、参数阈值、灵敏度和特异性			
	Adams测试	倾斜度（脊柱侧弯计）	铅垂线	Muar地形
Armstrong, 1982 [39]	(+)			
Grossman, 1995 [40]		(+) 5–7°		
De Wilde et al., 1998 [41]		(+) 5°; 变异系数 — 10%		
Grivas et al., 2002 [37]		(+) 7°		
Grivas et al., 2007 [16]		(+) 7°; 以坐姿而不是站立姿势进行检查		
Sabirin et al., 2010 [3]	(+)	(+) 7°		
Labelle et al., 2013 [17]		(+) 5–7°		
Elshazly et al., 2014 [42]	(+)	(+) 5°		
Komang-Agung et al., 2018 [43]	(+)	(+) 5° 敏感性95.6%. 特异性18.5%. (+) 7° 敏感性78.26%. 特异性88.88%		
Dunn et al., 2018 [44]	(+)	(+) 将Adams测试与脊柱侧弯测量仪结合使用： 灵敏度71.1%; 特异性97.1%; 假阳性2.9%; 假阴性28.9%		(+) 将所有三种测试结合起来： 灵敏度93.8%; 特异性99.2%; 预后价值81.0%; 假阳性0.8%; 假阴性6.4%
Adamczewska et al., 2019 [45]		(+) 5°; 胸椎和胸腰椎区域的角度值最高		
Yilmaz et al., 2020 [46]	(+)	(+) 5°		
Scaturro et al.,2021 [47]	(+) 特异性56.3 %	(+) 5° 特异性92.7 %	(+) 当铅垂线与Adams检测相结合时， 特异性为81.5%. 将所有三种测试结合起来： 特异性为99.7%	

率只有在进行高端保守治疗的情况下才能明显降低[55]。

不过，也有其他意见。例如，荷兰医生E.M. Bunge及其合著者[56]利用病例对照原则确定了筛查在减少手术治疗需求方面的有效性。通过筛查确定的手术患者年龄为10.8±2.6岁，手术前脊柱侧弯弓的Cobb角为54±8.2°，手术后为30±12.9°。其他手术患者的年龄为（13.4±1.7）岁，脊柱侧弯弓的Cobb角在术前为（57±11.7）°，术后为（33±10.2）°。两组患儿在手术前均使用过2.5年的躯干矫形器。因此，作者得出结论认为，他们并未获得确凿证据，证明通过筛查特发性脊柱侧凸可以减少手术需求。H. Labelle及合著者[8]和J.A. Deurloo，P.H. Verkerk [12]也持相同观点。

脊柱侧弯筛查在经济上可行吗?

香港科学家在一项以人口为基础的大型研究中对脊柱侧弯筛查计划的成本进行了全面估算[59]。每名学生的筛查成本（按2005年美元计算）为17.94美元，筛查和诊断测试的成本为20.02美元。此外，在19岁之前穿束身衣的治疗费用为8018美元，在19岁之前进行手术治疗和观察的费用至少为27538美元。这些计算结果与B.P. Yawn和R.A. Yawn以前的研究结果相当[60]。然而，从这些数据中无法得出筛查成本效益的结论。

从公共卫生和国际SRS专家组的角度来看，没有足够的证据支持青少年特发性脊柱侧凸筛查计划，因为筛查是否具有成本效益尚不清楚[8]。不过，有专家强调，应评估整个预防计划的成本效益，而不仅仅是临床背部检查和测试[12,28]。

H. Labelle等人[8]指出，由于不同的研究人员定义了计划成本、计划成本+诊断、计划成本++诊断+随访、计划成本+诊断+随访+治疗，因此很难直接比较筛查总成本。此外，这些成本应根据效率指标进行分析，即总成本的减少，例如由于避免了手术干预而减少的成本。作者强调，应通过分析可比情况来进一步研究筛查计划的成本效益。在这方面，可以使用标准化的医疗决策专用计算机程序[57]，包括智能手机应用程序[58]。

相比之下，J. Sabirin等人[3]和S. Thilagaratnam [61]指出，有证据表明学校脊柱侧弯筛查项目具有成本效益。SOSORT也赞同这一观点，认为如果干预措施组织得当并在自愿的基础上进行，例如效仿希腊学校筛查项目Thriasio的模式，筛查项目的直接成本就能降到最低[16]。

结论

反对筛查计划的主要论点与担心对青少年产生负面心理影响以及在筛查过程中侵犯儿童权利有关。他们还强调假阳性和假阴性的比例很高，以及缺乏有关成本效益的数据。然而，目前还没有研究评估不仅筛查而且全面治疗青年特发性脊柱侧凸患者的成本效益。

尽管有许多支持筛查的论点，但筛查的支持者并不否认，筛查的许多组织方面的问题尚未解决，也没有标准化。这些问题包括人员培训以及转诊和跟踪系统的开发。应通过引入非侵入性检查方法来统一筛查的计划和方法，以便使所获得的结果及其随后的统一解释标准化。

考虑到国际数据，似乎有必要制定一项全国筛查计划，作为治疗青年特发性脊柱侧凸患者的国家标准的一部分。应当考虑到，要成功实施这一项目，首先必须确保对接受筛查的儿童、需要保守治疗和手术干预的患者的信息进行集中的端对端收集。在这方面，开发并随后使用专门的计算机程序来支持医疗决策是可取的。

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