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体外磁刺激在泌尿外科的应用

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本文综述了体外磁刺激在泌尿系统疾病治疗中的应用。基于对PubMed、Medscape、Google Scholar数据库中的科学出版物的分析，关于该方法治疗效果机制的现代数据，介绍了执行该程序的方法，临床研究结果表明其在治疗中的有效性尿失禁、膀胱活动不足、慢性盆腔疼痛综合征、勃起功能障碍和早泄。

关键词： 体外磁刺激；尿失禁；慢性盆腔疼痛综合征；膀胱功能减退；勃起功能障碍。

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Review

Extracorporeal magnetic stimulation in urology

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The review article is devoted to the usage of extracorporeal magnetic stimulation in the treatment of urological diseases. Based on the analysis of scientific publications in the PubMed, Medscape, Google Scholar databases, modern data on the mechanism of the therapeutic effect of this method, the method of performing the procedure, the results of clinical studies of its effectiveness in the treatment of urinary incontinence, bladder hypoactivity, chronic pelvic pain syndrome, erectile dysfunction and premature ejaculation are presented.

Keywords: extracorporeal magnetic stimulation; urinary incontinence; chronic pelvic pain syndrome; bladder hypoactivity; erectile dysfunction.

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ECO•VECTOR

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Обзорная статья

Экстракорпоральная магнитная стимуляция в урологии

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Обзорная статья посвящена применению экстракорпоральной магнитной стимуляции при лечении пациентов с урологическими заболеваниями. На основе анализа научных публикаций в базах данных PubMed, Medscape, Google Scholar представлены современные данные о механизме лечебного эффекта данного метода, методике выполнения процедуры, приведены результаты клинических исследований его эффективности при лечении недержания мочи, гипоактивности мочевого пузыря, синдрома хронической тазовой боли, эректильной дисфункции и преждевременной эякуляции.

Ключевые слова: экстракорпоральная магнитная стимуляция; недержание мочи; синдром хронической тазовой боли; гипоактивность мочевого пузыря; эректильная дисфункция.

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ЭКО•ВЕКТОР

近年来，泌尿系统疾病患者治疗效果的提高在很大程度上与物理治疗和物理影响方法的发展有关[1-4]。其中一种方法是体外磁刺激（ECMS）。在特殊设备的帮助下进行ECMS时，会产生高强度的交变磁场，影响传入和传出神经纤维[1]。传出神经纤维中出现脉冲的后果是肌肉结构收缩，包括盆底肌肉；传入纤维的激活会影响盆腔器官的敏感性[4-8]。据信，在ECMS期间，下尿路功能的神经调节以这种方式发生[1,2]。

ECM的效果在很大程度上取决于外加磁场的频率。低频交变磁场（5-10 Hz）对阴部神经的影响会激发其传入纤维。通过它们，脉冲被传输到脊髓在那里有一个向脊髓上通路的开关，动作电位沿着该通路传播到脑干的排尿中枢。这种效应会导致排尿中枢的张力降低，并间接抑制副交感传出通路的活动，副交感传出通路的激活会导致逼尿肌收缩。在文献中，所描述的机制被称为抑制逼尿肌激活反射[9]。当暴露于交变磁场时，阴部神经的自主交感神经纤维去极化，以及脊髓胸腰椎和骶骨部分的细胞核活性增加。因此，下腹神经传出通路的交感神经活动、β3肾上腺素能受体的活动和逼尿肌松弛增加[10]。

根据J.S.Koh和合著者[11]低频ECMS在膀胱过度活动症中的额外治疗效果是由于刺激骶神经而抑制逼尿肌不自主收缩。刺激骶神经导致抑制性神经元间反射的激活，从而抑制影响膀胱张力增加的C型神经纤维的活动。这一事实可以解释ECMS在膀胱过度活动症和脊髓损伤患者中的有效性[11-13]。

暴露于高频ECMS(50-100 Hz)会激发阴部神经的交感传出纤维。这会导致盆底肌肉的张力和收缩增加，包括导致尿潴留的尿道外括约肌[10]。

对于混合性尿失禁，建议在每个疗程中结合使用低频和高频暴露[14]。这种方法可以有效地影响尿急和压力性尿失禁的发病机制。

研究结果表明ECMS后，血清中的肌生长抑制素浓度降低[13,15-17]。肌生长抑制素是肌肉组织生长的内源性抑制剂，其含量的增加可能是骨盆肌肉收缩力受损的原因之一。进行ECM有助于在生化水平上恢复盆底肌肉的功能。

在高频率ECM期间，盆底肌肉收缩后出现难治性传导期可以阻断病理性冲动和疼痛冲动[18]。这一机制在慢性盆腔疼痛患者使用ECM时很重要。

ECMS程序对患者来说是舒适的，无需脱掉衣服，将传感器应用或插入阴道/直肠，在ECMS期间，患者坐在一张特殊的椅子上。单独调整磁场强度，以对小骨盆的肌肉结构和器官实现无痛效果[19]。

ECMS对患者的心理社会领域有着有益的影响，并提高了生活质量。在ECMS之后，Beck抑郁量表II的得分显着降低，发现与尿失禁相关的身体和社会限制发作[20,21]。

ECMS期间盆底肌肉的连续收缩和放松有助于患者了解训练盆底肌肉的正确算法，并且可以与生物反馈方法相结合[13,22]。

压力性尿失禁

1998年ECMS在美国首次获批用于治疗压力性尿失禁。该方法的开发者之一是泌尿科医生N.T.Galloway[23]。N.T.Galloway[23]。1998年他的第一项研究评估了ECMS在压力性尿失禁中的有效性，包括83名女性。在手术过程中，患者坐在一张特殊的椅子上，交变磁波的来源在座椅下方。对于ECMS程序，前10分钟使用5 Hz的频率，然后从1到5分钟休息，接下来的10分钟—暴露于50 Hz。该程序每周重复两次，持续6周。治疗过程结束后3个月对83名接受治疗的患者中的50名进行了随访检查。同时，在17名（34%）女性中，完全没有出现尿漏，16名（32%）患者每天必须使用一个泌尿系统垫，只有剩下的17名（34%）患者每天使用一个以上的垫。ECMS结束后，使用的泌尿系统垫的数量从最初的每天2.5个减少到1.3个，平均垫重从20克减少到15克。其他研究人员也获得了类似的结果，证实了ECMS在女性压力性尿失禁患者中的有效性。根据A.Ünsal和合著者[24],ECMS治疗一年后，38%的患者没有压力性尿失禁症状，另有41%的患者表示其严重程度有所减轻。应该指出的是，这种影响至少持续了一年。显然，ECMS对压力性尿失禁的治疗效果与尿道内压升高有关。8因此，根据T.Yamanishi和合著者[25],ECMS后最大尿道内压增加34%（从72.0到96.5厘米水柱），最大尿道闭合压力增加20.9%（从68.3到82.6厘米水柱）[25]。

一项纳入232例压力性尿失禁患者的临床研究荟萃分析结果显示，经过ECMS疗程后，尿漏发作频率（平均每天1.42次）和尿量减少。泌尿垫重量平均减少4.99克）。同时，所有接受治疗的患者均未出现与使用ECMS相关的任何并发症[26]。

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紧急尿失禁

ECMS已成功用于治疗急迫性尿失禁患者。在对这种失禁患者进行的一项初步研究中，T.Yamanishii和合著者[25],在15分钟的ECMS会话之前和期间以10Hz的频率进行膀胱测压。他们发现在ECMS后，第一次排尿时膀胱充盈量显着增加，最大膀胱容量增加。A.Ünsal和合著者的研究结果证实了ECMS的有效性[24]。ECMS疗程结束后，17例治疗患者中有7例（41.2%）表示尿失禁停止，8例（47.1%）患者的严重程度降低。

T.Yamanishii和合著者[27]进行了一项随机对照试验，以10 Hz的频率和25分钟的持续时间对有急迫性尿失禁的女性进行ECMS的影响。会议每周进行两次，持续7周。该研究涉及151名患者，其中50名女性被纳入对照组。经过一个疗程的ECMS后，急迫性尿失禁的发作次数从每天2.65次减少到1.53次，失禁期间平均排尿量从14.03克减少到4.15克。对照组无明显变化[27]。

混合型尿失禁

建议混合性尿失禁患者进行高频和低频相结合的ECMS。根据D.D.Chandi和合著者[14],这种治疗方法对66.7%的患者有效，他们观察到排尿频率或尿失禁发作频率降低50%以上。然而，治疗前后的24小时垫测试结果没有显着差异。

P.M.Groenendijk和合著者[28]，根据尿失禁的形式，使用不同频率的ECMS。对于急迫性尿失禁患者，使用10Hz的低频持续20分钟；对于压力性尿失禁患者，使用50Hz的高频。在混合形式中，前10分钟以10Hz的频率进行ECMS，接下来的10分钟以50Hz的频率进行。60%的紧急尿失禁患者和66%的压力性和混合性尿失禁患者获得了成功治疗[28]。

根治性前列腺切除术后尿失禁

T.Yokoyama和合著者[29]对ECMS与盆腔肌肉电刺激治疗根治性前列腺切除术后尿失禁患者的疗效进行了比较研究。对照组由只进行凯格尔运动的患者组成。两个月后，ECMS或电刺激后的患者组尿潴留程度高于对照组。三组患者术后6个月才取得可比结果。

M.Nowak和合著者[30]也指出，在ECMS期间，根治性前列腺切除术后尿潴留的实现速度更快。在他们的研究中，105名患者被分为两组。实验组患者接受ECMS，对照组患者进行凯格尔运动。术后早期拔除导尿管后，16.8%的患者完全保留尿液。在进行ECMS时，分别有51%、64%和82%的患者在4周、3个月和6个月后实现了尿失禁。在凯格尔运动期间，分别有44%、50%和68%的患者出现尿潴留。12个月后，ECMS患者的测试结果明显优于对照组（p=0.004）。研究人员得出结论，ECMS显着加速了根治性前列腺切除术后患者尿失禁的恢复[30]。

在R.E.Amdiy和合著者[31]研究中确认ECMS治疗根治性前列腺切除术患者压力性尿失禁的疗效。对27名患者进行了20分钟的ECMS，频率为10和50Hz，每周2-3次，疗程为12次。治疗结束时，3名(11.1%)患者仍然大小便失禁，4名(14.8%)患者每天使用一个垫子，20名患者(74.1%)完全保留尿液。治疗结束后ICIQ-SF问卷总分由原来的12.9下降到3.7。

C.A.Anderson和合著者[32]发表了一项荟萃分析，对根治性前列腺切除术后尿失禁治疗中盆底肌肉训练、生物反馈、电刺激、ECM、加压装置的使用、生活方式改变的有效性进行了评估。荟萃分析的结果非常有争议，作者得出结论，需要额外的随机试验来评估不同类型治疗的长期效果。

慢性盆腔疼痛综合征与慢性前列腺炎

ECMS方法在慢性盆腔疼痛综合征的治疗中显示了其有效性。在M.H.Yang和合著者[4]研究中，ECMS已用于慢性盆腔疼痛患者，他们未能通过抗生素、α受体阻滞剂、非甾体抗炎药和神经营养药物的标准药物治疗[4]。23名患者接受了为期6周的ECM治疗（每周3次），频率为10和70 Hz，疗程为15分钟。在这项研究中，ECMS治疗后，美国国立卫生研究院慢性前列腺炎症状量表（NIH-CPSI）的总分下降了36.4%（从25.0分降至15.9分），疼痛域得分下降了44.1%（从11.8分降至6.6分），排尿障碍领域的总分下降了26.1%（从4.6分降至3.4分）。同时，患者的生活质量提高了31.4%（从8.6分提高到5.9分）。ECMS和生物反馈方法的联合使用提高了治疗效果。ECMS治疗后6个月和12个月，疼痛和下尿路症状持续减轻。应该注意的是，在减轻疼痛的严重程度方面效率最高[18,33]。T.H.Kim和合著者[34]的一项研究结果证实了联合ECM治疗慢性盆腔疼痛患者的有效性，他们在前15分钟使用10赫兹的低频刺激，在接下来的15分钟使用50赫兹的低频刺激。

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勃起功能障碍和早泄

ECMS在勃起功能障碍患者的治疗中得到了相当成功的应用。在这种情况下，磁性线圈可以内置在一个特殊的椅子上，也可以便携式，应用于阴茎背表面的底部。A.Shafik和合著者[35]为了影响海绵体神经，使用20赫兹的交变磁场频率。患者被分为治疗组和对照组，其中不进行电磁暴露。治疗组患者出现阴茎僵硬，而对照组没有变化。重复暴露阶段后，实验组患者再次出现勃起，但对照组患者没有勃起。所获得的数据表明，直接暴露在海绵体和深背神经上的交变磁场中以实现勃起的有效性。

R.B.Pelka和合著者[36]应用暴露在交变磁场脉冲下的频率为18赫兹。患者被随机分配到治疗组或对照组（每组10人）。在疗程结束时，第一组的8名患者（80%）报告勃起质量和持续时间有所改善。其余2名患者报告仅有轻微改善（20%）。在安慰剂组中，3名患者（30%）的总体情况有所改善，而其余7名患者（70%）的情况没有变化。

D.Yu.Pushkar和合著者[37]建议使用使用频率为6–8 Hz的ECM治疗勃起功能障碍，休息时间为3–4 s。为了达到效果，需要进行8–10次持续15–20分钟的程序。

ECMS也用于治疗早泄[38]。其作用机制是降低脊髓射精中枢的张力。当暴露在20赫兹的频率下时，阴道内潜在射精时间持续增加，这与治疗过程的持续时间直接相关。这种治疗的结果与行为和药物治疗相当。

ECM对勃起功能恢复的影响的许多方面尚不清楚，需要进一步研究，尤其是选择最佳暴露模式[31]。

膀胱活动不足

骶骨刺激是治疗逼尿肌活动不足的有效方法[39]。其作用机制与排尿中枢的神经调节有关[40]。R.E.Amdia和合著者的初步研究[41]显示了在逼尿肌活动减退的患者中使用ECM的可能性。当使用与骶骨刺激频率相同的ECM时，37.5%的患者症状改善，残余尿量减少。

结论

ECMS在盆腔器官疾病的泌尿外科实践中已显示出其有效性，并且由于其对深部结构的无创无痛效应，与许多其他保守的泌尿外科疾病治疗方法相比具有优势。该方法易于使用，禁忌症最少，不需要昂贵的耗材。

生理效应在很大程度上取决于ECM的频率。交变磁场的低频（5–15 Hz）通过降低骶髓排尿中枢的张力以及放松逼尿肌和盆底肌肉的效果，在急迫性尿失禁的治疗中是有效的。高频（50 Hz）作用于盆底肌肉的运动神经元，导致其收缩和训练，形成对患者收缩算法的正确理解。ECMS作用机制的一个方面是神经系统活动的神经调节，这是盆底器官和肌肉的传入神经兴奋的结果。

需要进一步的实践和研究工作来确定适应症，选择患者，并确定暴露于ECM的最有效模式。

附加信息

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