



# Medical Treatments of Peyronie's Disease: Past, Present, and Future

Daan C.J. Mohede, Igle Jan de Jong, and Mels F. van Driel

**P**eyronie's disease (PD) is a benign fibroproliferative disorder, which causes the formation of plaque in the tunica albuginea of the corpora cavernosa in the penis. The disease is named after François Gigot de la Peyronie (1678-1747), although Fallopius and Vesalius had already described the disorder in 1561.<sup>1</sup>

Since the time of Peyronie, who sent his patients to the holy water of Baragès in the French Pyrenees,<sup>2</sup> many non-surgical empirical approaches have been tried in an attempt to cure PD, but there is still no effective cure. This is mainly due to a lack of understanding concerning the biology and pathology of PD.<sup>3</sup> Once a calcified or even ossified plaque has developed, there is no nonsurgical treatment to make it disappear.

In 2004, Ralph and Minhas found 38 nonsurgical treatments of PD.<sup>4</sup> At the time of writing, none of them has received a grade A recommendation under the American and European guidelines.<sup>5,6</sup> Collagenase from *Clostridium histolyticum* is the only drug approved by the United States Food and Drug Administration and the European Medicines Agency for intralesional injection in patients with palpable plaque and dorsal or dorsolateral curvature greater than 30°, smaller than 90°, and intact erectile function.

In the acute phase, PD is treated conservatively (non-steroidal anti-inflammatory medications may offer analgesia) and, in general, surgical approaches are only attempted after around 1 year in patients for whom the disease has not worsened for at least 3 months and who have a curvature that impedes sexual intercourse. During that waiting time, patients are often willing to undergo treatments. The effectiveness of these treatments, however, has not been proven in a 3-arm study design (test treatment vs placebo vs no treatment) with an 18-month duration. In this article, we reflect on the past, present, and future of nonsurgical treatments of PD, with the emphasis being on oral treatments.

**Financial Disclosure:** The authors D.C.J. Mohede and I.J. de Jong declare that they have no relevant financial interests. M.F. van Driel is speaker for Lilly and GSK.

From the Department of Urology, University of Groningen and University Medical Center Groningen, Groningen, the Netherlands

Address correspondence to: Daan C.J. Mohede, M.D., Department of Urology, University Medical Center Groningen, CB62, PO Box 30001, 9700 RB Groningen, The Netherlands. E-mails: [d.c.j.mohede@umcg.nl](mailto:d.c.j.mohede@umcg.nl); [daan\\_ys\\_mohede@hotmail.com](mailto:daan_ys_mohede@hotmail.com)

Submitted: October 22, 2018, accepted (with revisions): January 3, 2019

## MATERIALS AND METHODS

An extensive literature search (*The Cochrane Library*, *PubMed/MEDLINE*, *Web of Science*, *EMBASE* and old German, Dutch, French, and English medical books on male sexual functioning) was performed with the searches spanning until January 2018. The search included all medical interventions in patients with PD (or “cavernositis,” “penile fibrosis,” “fibrous sclerosis of the penis,” “induratio penis plastica” or “Van Buren's disease”), as reported in articles in any of the previously mentioned databases, or others found as references in articles and antiquarian books. We discuss our overall findings.

## RESULTS

In all consulted databases and references, researchers found a total of 48 nonsurgical interventions in articles published from 1743 to 2017. These included 11 external, 11 intralesional, 7 topical and 23 oral interventions (Table 1). A further four of the treatments comprised a combination of two of the nonsurgical interventions.

## DISCUSSION

Nowadays, surgery is of minimal value in patients with peptic duodenal ulcers, pulmonary tuberculosis or anus carcinoma. For those disorders, effective nonsurgical treatments have replaced mutilating surgery. This is not yet the case for PD.

Throughout the past 3 centuries, many medical treatments have been tried, but nearly all were reported after clinical studies with a low number of patients and/or based on anecdotal experiences. In 1968, for example, Aron noted a regression of Dupuytren's disease in a patient who was treated with the cytotoxic procarbazine for Hodgkin's disease, and he suggested the use of this drug in fibroproliferative disorders.<sup>34</sup> In the 1970s, investigators from France reported excellent results in patients with PD, but in Belgium, procarbazine had disappointing results.<sup>55,56</sup> It is interesting to note that many titles of the articles on PD treatments used the words “new therapy.”

The modern era of trial and error in the medical therapy of PD began in 1949 with Scardino's report on the use of tocopherols.<sup>24</sup> Teasley first reported successful intralesional corticosteroid injections in 1954.<sup>25</sup> However, because a widely accepted and effective medical treatment for PD was unavailable, research was primarily

**Table 1.** Historical overview of first reports about nonsurgical interventions for PD.

Year	Therapy	O/T/I/E	Authors
1743	Mercury and mineral water	O	De la Peyronie <sup>2</sup>
1840	Potassium iodide	O/T	Ricorsd <sup>7,*</sup>
1864	Electricity	E	Van Buren <sup>8,*</sup>
1876	Bromides and hyperthermia	O/E	Hodgen <sup>9,*</sup>
1878	Mercury and iodides	O/T	Curling <sup>10</sup>
1890	Sulfur	O	Dubuc <sup>11,*</sup>
1896	Copper sulfate	O	O'Zoux <sup>12,*</sup>
1901	Salicylate and thiosinamin	O	Sachs <sup>13,*</sup>
1901	Mercury and iodides	I	Walsham <sup>14</sup>
1902	Arsenic	O	Reliquet <sup>15,*</sup>
1907	Fibrinolysin	O/T	Waelsch <sup>16,*</sup>
1910	Ionization	E	Lavenant: quoted by Zislin <sup>17,*</sup>
1911	Milk	O	Van der Pool <sup>18,*</sup>
1911	X-radiation	E	Bernasconi <sup>19,*</sup>
1912	Ultraviolet light	E	LeFur <sup>20,*</sup>
1922	Trypsin	I	Sonntag <sup>21,*</sup>
1922	Radium	E	Kumer <sup>22,*</sup>
1943	Diathermy	E	Wesson <sup>23</sup>
1943	Di-sodium phosphate	O	Wesson <sup>23</sup>
1949	Vitamin E	O	Scardino <sup>24</sup>
1954	Cortisone	I	Teasly <sup>25</sup>
1954	Hyaluronidase and steroid	I	Bodner <sup>26</sup>
1955	Oestrogens	O	Minder <sup>27</sup>
1959	Potassium para-aminobenzoate	O	Zarafonitis <sup>28</sup>
1960	Histamine iontophoresis	T	Whalen <sup>29</sup>
1963	Prednisolone	O	Chesney <sup>30</sup>
1967	Ultrasound	E	Heslop <sup>31</sup>
1967	Dimethyl sulfoxide	O	Persky <sup>32</sup>
1967	Steroid iontophoresis	T	Rothfeld <sup>33</sup>
1970	Procarbazine	O	Aboulker <sup>34</sup>
1975	Parathyroid hormone	I	Morales <sup>35</sup>
1981	Orgoteine	I	Bartsch <sup>36</sup>
1983	Beta-aminopropionitrile	T	Gelbard <sup>37</sup>
1985	Collagenase	I	Gelbard <sup>38</sup>
1985	Laser	E	Puente de la Vega <sup>39</sup>
1988	Prostacyclin	I	Strachan <sup>40</sup>
1989	Lithotripsy	E	Bellorofonte <sup>41</sup>
1991	Interferon	I	Benson <sup>42</sup>
1992	Tamoxifen	O	Ralph <sup>43</sup>
1994	Verapamil	I	Levine <sup>44</sup>
1994	Colchicine	O	Akkus <sup>45</sup>
2001	Carnitine	O	Biagiotti <sup>46</sup>
2001	Traction devices	E	Scroppo <sup>47</sup>
2003	PDE5-I & arginine	O	Valente <sup>48</sup>
2006	Pentoxifylline	O	Brant <sup>49</sup>
2009	Omega-3 fatty acids	O	Safarinejad <sup>50</sup>
2010	Nicardipine	I	Soh <sup>51</sup>
2016	Superoxide-dismutase nicardipine and emu oil	T	Twidwell <sup>52</sup>

E, external; I, intravesical; O, Oral; T, topical

\*Cited in<sup>53</sup>

done by surgically-orientated urologists. They understandably focused on operation techniques, which led to them neglecting the pursuit of medical therapies. The only exceptions were the collagenase protocols of 1993 and the collagenase clostridium histolyticum injection therapy in the last decade. Collagenase was the only subject of study in which the effects were evaluated in a randomized, placebo-controlled, double-blind manner. Moreover, this was preceded by animal studies.<sup>57</sup> One of the few other animal studies showed a reduction of fibrosis in the tunica albuginea when the rats consumed

pentoxifylline, L-arginine or any of three PDE-5 inhibitors (sildenafil, vardenafil, and tadalafil) through drinking water.<sup>48</sup> The authors hypothesized that the increase in NO and/or cGMP/cAMP levels by chronic administration of nitrenergic agents or PDE inhibitors could be effective in reversing the fibrosis of PD and, more speculatively, other fibrotic conditions.

In the American and European guidelines, none of the options depicted in the table carries a grade A recommendation. Today, drugs such as carnitine, arginine, and dimethyl sulfoxide belong to the domain of complementary

and alternative medicine in most European countries. Another alternative treatment available on the internet is bromelain, which is the crude extract of pineapple and has fibrinolytic, antithrombotic, and anti-inflammatory properties.<sup>58</sup> However, there are no scientific data about its use by PD patients. According to the National Center for Complementary and Integrative Health in the United States, bromelain is available as a powder, cream, tablet, and capsule.

Overall, oral medical treatments are considered potentially effective only in the early phase of PD, that is, before plaque hardening and calcification occur. According to the current European guidelines, oral steroids, vitamin E and tamoxifen should be avoided completely as treatment. The American Urological Association (AUA) added procarbazine, omega-3 fatty acids and the combination of L-carnitine with vitamin E to their list of treatments to avoid. The remaining drugs for off-label use are pentoxifylline, a PDE-5-inhibitor and/or arginine, or a combination of these. The AUA guidelines from 2015 report that pentoxifylline (whether or not combined with intralesional verapamil and traction) can reduce pain and ED.<sup>6</sup>

Since the release of the 2015 AUA guidelines, an Italian study showed that treatment that combined pentoxifylline with minor antioxidants (propolis, blueberries, and vitamin E) and topical diclofenac was effective in patients with early-stage PD.<sup>59</sup> This study also demonstrated that the clinical efficacy of pentoxifylline was greater when administered both orally and locally through perilesional injection.

## CURRENT KNOWLEDGE AND NEW DRUGS FOR FIBROSIS

In all fibroproliferative diseases, the differentiation and activation of myofibroblasts is one of the most important processes. These cells are the main producer of collagen and other extracellular matrix components. They also contain  $\alpha$ -actin, which is a protein that causes cell contraction and thus contributes to distortion and dysfunction.<sup>60</sup> Myofibroblasts originate from locally-present fibroblasts or differentiated infiltrating fibrocytes.<sup>61</sup> Fibrocytes are circulating connective tissue progenitor cells. The transformation of precursor cells to myofibroblasts is influenced by various growth factors, cytokines, and clotting factors. As the healing process progresses, the myofibroblasts will eventually disappear by apoptosis. It has been hypothesized that deregulation of this apoptotic process can occur, thus allowing more myofibroblasts to remain active.<sup>62</sup> Additionally, there are indications that epigenetic changes in fibroblasts or myofibroblasts may contribute to fibrotic changes.<sup>63,64</sup> Nowadays, as in PD, there are largely ineffective therapeutic options for patients with fibrotic diseases in general. New agents under investigation are pirfenidone, tyrosine kinase inhibitors, transforming growth factor- $\beta$ , platelet-derived growth factor, interleukin-13, and lysyl oxidase-2.<sup>65</sup>

Pirfenidone is an expensive, small molecule that is available for oral use. The exact molecular mechanism of action is not completely explained. Based on in vitro studies, it is assumed that pirfenidone inhibits the proliferation and synthesis of profibrotic and inflammatory mediators, and the collagen synthesis by fibroblasts and myofibroblasts. It is the first specific antifibrotic agent that is approved for the treatment of patients with idiopathic pulmonary fibrosis in Europe, Japan, and the United States.<sup>66</sup> New studies could show whether pirfenidone works in patients with fibrotic diseases other than idiopathic pulmonary fibrosis.

The protein tyrosine kinase inhibitor nintedanib seems to be successful in the treatment of patients with pulmonary fibrosis, while some forms of systemic sclerosis seem to decrease after treatment with the protein tyrosine kinase inhibitor imatinib mesylate.<sup>67,68</sup> These new treatment options, however, are not yet beyond phase II studies in patients with idiopathic pulmonary fibrosis. It remains to be seen whether these therapies can also be applied in the treatment of patients with other fibrosing disorders.

## CONCLUDING REMARKS

Many of the old and new drugs reviewed have a reasonable basis for their use, but the lack of basic research on the biology and pathology of PD makes it difficult to understand the working mechanisms. The most important goal of medical therapy is to prevent or halt the process of plaque formation and scarring. Patients typically present pain during the acute phase. If the plaque begins to harden, oral drugs will not be delivered. This is most likely due to the decreased vasculature. Therefore, pharmacotherapy should be initiated as soon as possible in the acute phase of PD.

Nowadays, patients may use pentoxifylline, a PDE-5-inhibitor, antioxidants or a combination of this off-label. Antioxidants belong to the domain of complementary and alternative medicine.

The search for new, well-tolerated and effective medical therapy has to continue. In the end, the management of PD should improve, with fewer patients needing surgery. In that respect, we strongly recommend close collaboration with nonsurgical experts in fibrotic diseases.

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