Objective: To analyze and compare the incidence and visual characteristics of blood vessels on the superior surface of vocal folds with polyps, nodules, and minimal structural alterations (ie, sulci, cysts, and mucosal bridges).

Design: Cross-sectional study.

Setting: Academic research.

Patients: A total of 280 videolaryngoscopic images were randomly selected and classified into the following 4 groups of 70 patients each: the vocal nodule (VN) group, the polyp group, the minimal structural alterations (MSA) group, and the control group.

Main Outcome Measures: Laryngoscopic images were assessed for visible blood vessels and for the orientation and characteristics of the vessels. Isolated ectasias with clear boundaries were excluded.

Results: The highest incidence of visible vessels was observed in the MSA group (91.4%), followed by the polyp (77.1%), VN (44.7%), and control (31.4%) groups. Longitudinal and transverse vessels were found more frequently in the MSA (74.3% and 37.1%) and polyp (65.7% and 22.9%) groups than in the VN (34.3% and 12.9%) and control (25.7% and 5.7%) groups. Tangled vessels were found only in the MSA group (8.6%). Abrupt changes in the caliber of the vessels and sinuous vessels were observed only in the polyp (21.4% and 5.7%) and MSA (61.4% and 27.1%) groups.

Conclusions: The main differences in the incidence and characteristics of visible blood vessels occurred between 2 pairs of groups: MSA-polyp and VN-control. The incidence was significantly higher in the MSA group than in the polyp group, and the incidence in both the MSA group and the polyp group was also significantly higher than that in the VN and control groups. The greatest variations were found in the MSA group, including the presence of tangled blood vessels (which was observed only in this group).


Investigations of the histologic structure of the vocal folds can provide clinicians with objective knowledge about voice physiology and may elucidate the reasons why minor modifications can cause a dramatic impact on voice production. As opposed to acquired lesions, such as vocal nodules (VNs) and polyps, alterations in the vocal folds such as epidermoid cysts, vocal sulci, and mucosal bridges (often observed together) have been categorized as congenital anomalies by Bouchayer et al. and Arnold previously described these entities as “minor anomalies of the vocal cords.” In the present study, we also considered cysts, sulci, and mucosal bridges to be congenital alterations of the structure of the vocal folds and grouped these abnormalities under the term minimal structural alterations (MSAs). Despite the many technological advances, the clinical diagnosis of so-called minor anomalies of the vocal folds remains difficult, mainly because of their subtle visual characteristics and their visual similarity to acquired lesions, especially VNs, particularly when a contralateral lesion is present.

Traditional stroboscopy has proved to be a powerful diagnostic resource, allowing observation of absent or markedly reduced vibration of the mucosal wave in the affected region, frequently associated with MSAs. Moreover, the presence of discernible vessels with dilatations, tortuous shapes, or transverse orientation has been associated not only with vocal abuse.
but also with benign lesions such as nodules,\(^9\) polyps,\(^8,10,11\) and MSAs.\(^2,6\) Vascular dilations that have been observed by laryngoscopy on the mucosal surface of the vocal folds (referred to as capillary ectasias, angiectasias, or varices\(^8,12\)) have been reported as being indirect signs of the presence of cysts.\(^1,2,13,14\) Reports have also suggested that the ectasias and varices that sometimes occur in association with other abnormalities could be related to vocal trauma.\(^8,15\) In fact, the exact correlations between benign lesions, phonotrauma, MSAs of the vocal folds, and the presence of visually distinguishable blood vessels have not been clearly determined to date. The main hypothesis of this study is that the presence of alterations in the caliber and orientation of visible blood vessels (compared with the normal longitudinal disposition and uniformly slender diameter) could be related to histologic modifications of the vocal folds’ layered structure, usually found in MSAs. The goals of this study were to analyze and compare the incidence and visual characteristics of blood vessels on the vestibular surface of the vocal folds through videostrobolaryngoscopic images of patients clearly diagnosed as having MSAs, polyps, and VNs as well as those of a control group with no vocal complaints or laryngeal lesions.

### METHODS

A total of 280 videostrobolaryngoscopic examinations were randomly selected from 70 patients (age range, 25-45 years) who were separated into 4 groups: patients with polyps, patients with VNs, patients with MSAs (including epidermoid cysts, sulci, and mucosal bridges), and patients with no vocal complaints or laryngeal lesions (controls). Cases involving concomitant abnormalities were excluded. The diagnoses were exclusively clinical: no surgical inspections or anatomopathologic examinations were performed. Stroboscopy was performed to differentiate between VNs and cysts. We made the diagnosis together and judged the characteristics of the vessels. Cases of uncertain diagnosis were excluded. The VN diagnosis was confirmed by improvement of voice after phonotherapy, with reduction in size or complete absorption of the nodular lesion as well as the contralateral reaction. This information was obtained from the patient’s history files, medical charts, and videostroboscopy records. Images of the control group were obtained by means of routine inspections of professional voice users as well as from examinations that were performed to exclude laryngeal abnormalities in patients.

For each image, the following aspects were observed: (1) the presence or absence of visible blood vessels on the vestibular surface of the vocal folds; (2) the number of individuals in each group with visible vessels; (3) the orientation of the vessels (ie, longitudinal [along the vocal fold], transverse [across the length of the vocal fold], or tangled [no defined direction]); and (4) any tortuosity, dilatation, or abrupt reduction in the caliber of the vessels. Figure 1 shows normal vocal folds with and without visible vessels, while Figure 2 shows representative examples of the evaluated aspects of the vessels’ characteristics. Ectasias characterized by isolated prominent dilations with clear boundaries were not included in the study because they were not considered as modifications on the vessel’s path (Figure 2D). The $x^2$ test and the $x^2$ partition test were used to analyze the results, and $P < .01$ was considered significant. The work was submitted to and approved by the local ethics committee.

### RESULTS

The following 3 equations were used to summarize the statistically significant results (all $P$ values < .01): (1) MSA (91.4%) > P (77.1%) > VN (45.7%) = Ctrl (31.4%), for visually observable vessels (Table 1); (2) MSA (74.3%) = P (65.7%) > VN (34.3%) = Ctrl (25.7%), for longitudinal vessels (Table 2); and (3) MSA (37.1%) = P (22.9%) > VN (12.9%) = Ctrl (5.7%), for transverse vessels (P and Ctrl represent the polyp group and the control group, respectively). Tangled vessels were found only in the group with MSAs (8.6%).

Regarding the caliber of the vessels, no significant abrupt reduction, dilatation, or tortuosity was observed in the control or the VN group (Table 3); however, these modifications were observed in the polyp group (dilatations, 14.3%; abrupt reductions, 21.4%) and even more frequently in the MSA group (dilatations, 34.3%; abrupt reductions, 61.4%; $P < .01$), which included cysts, sulci, and mucosal bridges. The incidence of tortuosity was significantly higher in the group with MSAs than in the other groups ($P < .01$): MSA (27.1%) > P (5.7%) = VN (0.0%) = Ctrl (0.0%).

### COMMENT

The presence of abnormal blood vessels associated with laryngeal polyps is widely reported in the literature. Roch et al\(^13\) observed vascular lines on the vocal folds in 10% of patients diagnosed as having polyps. Stemple et al\(^16\) found distinguishable blood vessels feeding polyps. Sataloff\(^17\) described an abundant distribution of blood vessels running into the base of the polyp, probably as a result of the inflammatory process, as suggested by Kambic et al.\(^10\) The findings of our study are in general agreement with those studies regarding the presence of blood vessels associated with polyps (77% of our cases). According to Hirano\(^1\) and Kambic et al,\(^10\) the vessels associated with polyps exhibit vasodilatation and increased vascular permeability, which helps make them visible. Kleinassser\(^18\) studied the pathogenesis of polyps and suggested that trauma to the walls of the vessel could cause vasodilatation, increased permeability, and even the appearance of raveled and tortuous vessels. In regard to
MSAs, Bouchayer et al.² made reference to the presence of inflammatory cells in histologic laminas of cysts and sulci, suggesting an underlying chronic inflammatory process. We concur with this statement and hypothesize that these intrachordal inflammatory processes may explain the high incidence of visually distinguishable blood vessels associated with MSAs (Table 1).

In our study, the incidence of longitudinally oriented vessels was also significantly higher (P < .01) in the MSA and polyp groups than in the VN and control groups.

Table 1. Incidence of Observable Blood Vessels in the Minimal Structural Alterations (MSA), Polyp, Vocal Nodule (VN), and Control Groups

<table>
<thead>
<tr>
<th>Observable Blood Vessels</th>
<th>Control</th>
<th>VN</th>
<th>Polyp</th>
<th>MSA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>22 (31.4)</td>
<td>32 (45.7)</td>
<td>54 (77.1)</td>
<td>64 (91.4)</td>
<td><strong>172</strong> (61.4)</td>
</tr>
<tr>
<td>Absent</td>
<td>48 (68.6)</td>
<td>38 (54.3)</td>
<td>16 (22.9)</td>
<td>6 (8.6)</td>
<td><strong>108</strong> (38.6)</td>
</tr>
<tr>
<td>Total</td>
<td><strong>70</strong> (100)</td>
<td><strong>70</strong> (100)</td>
<td><strong>70</strong> (100)</td>
<td><strong>70</strong> (100)</td>
<td><strong>280</strong> (100)</td>
</tr>
</tbody>
</table>

Table 2. Distribution of Longitudinal, Transverse, and Tangled Blood Vessels in the Minimal Structural Alterations (MSA), Polyp, Vocal Nodule (VN), and Control Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>VN</th>
<th>Polyp</th>
<th>MSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal²</td>
<td>Present</td>
<td>18 (25.7)</td>
<td>24 (34.3)</td>
<td>46 (65.7)</td>
</tr>
<tr>
<td>Transverse²</td>
<td>Present</td>
<td>4 (5.7)</td>
<td>9 (12.9)</td>
<td>16 (22.9)</td>
</tr>
<tr>
<td>Tangled²</td>
<td>Present</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td><strong>70</strong> (100)</td>
<td><strong>70</strong> (100)</td>
<td><strong>70</strong> (100)</td>
<td><strong>70</strong> (100)</td>
</tr>
</tbody>
</table>

No statistically significant difference was found between the polyp and MSA groups (P = .35) or between the VN and control groups (P = .35). Existence of visible lon-
Vertical vessels in normal larynges has been reported by many authors, some of them suggesting that the vessels probably result from chronic mechanical trauma to the microvascular reticulation of the vocal folds. Findings in our study contradict this assumption, because the incidence of visible longitudinal vessels in the VN group (in which the pathogenesis was predominantly related to phonotrauma) was not significantly different from that in the control group \((p = .35)\) and was significantly lower than that in both the MSA and polyp groups \((p < .01)\). For this reason, we believe that, rather than being related to phonotrauma, visible blood vessels would be related to inflammatory processes, predominantly located at the lamina propria.

The incidence of transverse vessels was significantly higher in the MSA and polyp groups \((p < .01)\) than in the control and VN groups (Table 2). Normally, the vascularization of the vocal folds has a longitudinal orientation, following the fibers that support the vessels. Behlau and Pontes described the presence of dilated transverse-oriented vessels in vocal folds with MSAs. Sato and Hirano identified modifications in the fibroblasts of the macula flava in patients with vocal sulci. They also described a region-specific increase in the number of collagen fibers that were densely distributed throughout the concavity of the sulcus and extended from it in different directions. Such structural distribution of fibers could also be a common finding in the group of vocal alterations classified as MSAs and could explain the modifications of the vessels’ characteristics. If such structural changes were present in patients with MSAs who were exposed to constant phonotrauma, general vasodilation would make the transverse vessels more evident.

Although tangled vessels were rare in our study and were observed in only 6 cases, all of them occurred in the MSA group, and although the 6 cases represent a small number of patients, the presence of tangled vessels may be a pathognomonic diagnostic sign of MSAs. The incidence of tortuosities, dilatations, and abrupt reductions in the vessels’ caliber was significantly high \((p < .01)\) in the MSA and polyp groups and null in the VN and control groups. Because the path of the vessels is related to the disposition of the collagen and elastic fibers of the vocal folds, structural disruptions or heterogeneity might explain the abrupt changes in caliber and orientation that were observed in these cases, whereas normal distribution and integrity of the elastic and collagen fibers would more likely result in a uniform and harmonic narrowing of the vessels. Therefore, in regard to the MSAs, modifications in the orientation of the vessels could be the result of disruptions and heterogeneity in the fibrous proteins of the lamina propria.

The development of polyps, characterized by histologic alterations that are not limited to the epithelium, might modify the disposition of the vessels, which would then dilate and become visible on simple laryngoscopic observation.

With respect to clinical diagnosis, the major remaining difficulty is distinguishing between VNs and cysts. In our study, there were marked differences in the incidence, characteristics, and orientation of the visible blood vessels between the patients with VNs and those with cysts. Therefore, it is safe to state that, in cases where there are doubts in the differential diagnosis between VNs and cysts, the presence of visible vessels with transverse orientation, abrupt reduction, dilatation, and tortuosities suggests an increased possibility that the lesion is a cyst. The identification of blood vessels and the observation of their orientation and characteristics may be important to the clinical diagnosis.

In conclusion, the main difference in the incidence or characteristics of the vessels occurred between 2 pairs of groups: MSA-polyp and VN-control. The incidence was significantly higher in the MSA group than in the polyp group, and the incidence in both groups was also significantly higher than in the VN and control groups. Alterations in the caliber and orientation of blood vessels of the vocal folds were more frequent in the MSA group. It is difficult to differentiate between VNs and cysts using clinical resources alone. However, the analysis of the presence and characteristics of visible vessels on the surface of the vocal folds may facilitate the differential diagnosis.

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Author Contributions: Drs De Biase and Pontes had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: De Biase and Pontes. Acquisition of data: De Biase and Pontes. Analysis and interpretation of data: De Biase and Pontes. Drafting of the manuscript: De Biase and Pontes. Critical revision of the manuscript for important intellectual content: De Biase and Pontes. Obtained funding: Pontes. Administrative, technical, and material support: Pontes.

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